In Two Parts—Part One

THE JOURNAL OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

ACCOUNT OF THE WORCESTER MEETING

JULY ~ 1918

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THE SPRING MEETING

THE Spring Meeting of 1918 is destined to go down in the annals of the Society and to become generally known as "The Great Worcester Meeting." It was great in attendance, with a registration of 472 members and 514 guests, a total of 986—much the largest Spring Meeting of the Society; it was great in practical accomplishment in the interests of the Society and its work, particularly in relation to the war; and it was great in the good-fellowship and hospitality displayed by the citizens of Worcester and provided for with such admirable care by the members of the Local Committee.

It was very evident to those arriving that they were expected guests and that the people of Worcester were prepared to extend a royal welcome. Throughout the city, in every business window, was displayed an artistic placard bearing the emblem of the Society and announcing the convention. For days previous there had been articles on the Society and its meeting in the daily press, and it should be said in this connection that the publicity both before and during the convention, due to the effective work of the local Printing and Publicity Committee, was the most extensive the Society has ever received.

Worcester Polytechnic Institute where the Members were Cordially Welcomed and Most of the Professional Sessions were Held

In the Hotel Bancroft, the headquarters, a large electric sign heralded the meeting, and at the registration desk every one received a handsome brochure and entertainment program issued by the local committee. The ballroom of the hotel was appropriately decorated, as shown in the view on the following page.

Professional sessions, however, were mainly held in the several large halls of the Worcester Polytechnic Institute, splendidly adapted for this purpose. Here the decorations were simple but effective, comprising the flags of the Allies. The opening session was in the large new gymnasium of the Institute, and on the first day of the meeting luncheon was served in the electrical engineering laboratories. These laboratories are large and extensively equipped, easily affording space for serving the four hundred or more in attendance at the first session. The Society was particularly fortunate in having these facilities, and it was a pleasure to the members to be able to spend so much time at the Institute, where inspection could be made of its laboratories, shops and general equipment. No small part of the pleasure was to be greeted there by Dr. Hollis, president of the Institute and former president of the Society.

The large attendance at the meetings was no doubt due in part to the fact that Worcester is the "center," as one speaker expressed it, "of a circle of 50 miles radius, in which is a population of 4,000,000 people," a large number of whom are engaged in the industries. It is convenient of access to many of our members. Through the coöperation also of the Boston Local Section, the Providence Engineering Society and the New York Section, delegations came to the meeting, which swelled the attendance.

Professional Sessions

An account of the several sessions is given in this number of The Journal, and one, on The Economical Use of Fuel, resulted in so large an amount of contributed discussion of vital importance to the fuel question at the present time that it has been made a supplement to The Journal, issued as Part 2 of the present number. The spirit of the war and the service which the engineer must render, not only as a citizen, but because of his special attainments, pervaded the whole meeting. The papers at the New England Day Session on Wednesday very largely discussed war problems, and at the meeting on Emergency Technical War Training on Thursday there were ringing addresses which enthused the audience and impressed all with the responsibilities which must be assumed in preparing men for technical service. There were the usual technical papers on general subjects and an interesting session at the Norton Companies' plants, the latter relating to the housing of workmen and employees and work for the betterment of conditions existing among employees and of their relations to their firms.

Ballroom of Hotel Bancroft Decorated for the Meeting

Spring Meeting Entertainment

It was the evident purpose of the Local Committee at Worcester that, however restricted transportation facilities might be in the future, every one at the Worcester meeting, at least, should have an opportunity to ride. Special trolley cars were provided and owners of automobiles in the city freely contributed their machines so that every visitor was transported to or from the points which he wished to visit. Besides this, there were automobile trips for the ladies and the memorable all-day trip on Friday, which were enjoyed to the fullest extent.

While automobiling was a characteristic feature, it was, however, only incidental to the several social affairs which the Committee provided. These opened brilliantly on Tuesday evening, following the more formal proceedings at the hotel, by a reception at the Art Museum and a dance at the Woman's Club building adjoining, which is one of the fine club buildings of the country. This was the first affair of the kind ever held in the beautiful rooms of the Museum, and it made a most favorable impression upon every one as the initial event of the convention. Exquisite music was rendered by Boston opera players. Tuckerman Hall, where the dance was held in the Woman's Club Building, was attractively decorted with huge masses of peonies and roses. Dancing continued until a late hour and refreshments were served throughout the evening.

Trip to the Norton Companies' Plants

On Thursday noon the members and guests were conveyed either by automobile or special train to the Norton Companies' plants, where a bountiful buffet lunch was served in Plant 6 dining room. Trips were projected for the afternoon to the model homes of the Norton employees at Indian Hill; to the company's farm gardens and to various departments of the manufacturing plants, especially that of the Norton Grinding Company, to witness a demonstration of grinding machines on Government work. The weather was rainy during the early part of the afternoon, so that these plans could not be fully carried out. Nevertheless, between showers several trips were made, and the afternoon was pleasantly spent.

It may be of interest to add that the large new athletic field and ball grounds, which were pointed out to the visitors, have since been dedicated by a large meet of the employees at which athletic games were held.

Coincident with the trips mentioned was the professional session, at which valuable information was given about the employees' service work of the Norton Companies, a report of which appears elsewhere in this number.

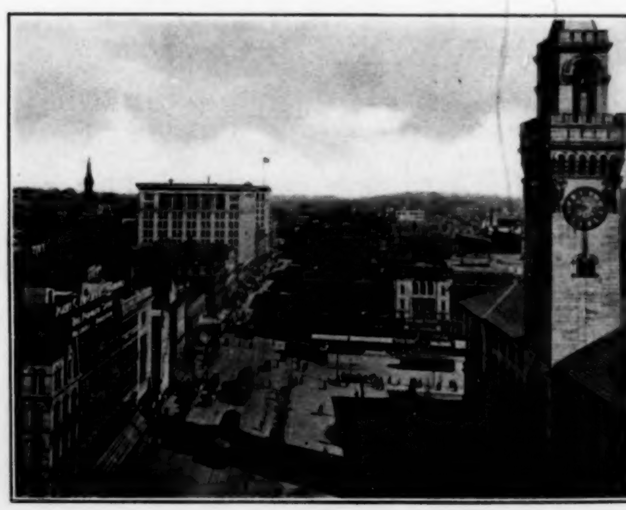
Delightful Evening at the Worcester Country Club

On Thursday evening was the garden party at the Worcester Country Club, the closing festivity. The location of the club, with its broad view of green slopes and foliage, is ideal, and the long evenings of daylight which we are now enjoying contribute greatly to the success of an evening party such as was here held. The club building has a large tiled terrace, where a buffet supper was served. The decorations were elaborate, and had been made under the direction of a Worcester architect, to give the effect on the terrace of an Italian garden, with well curb, statuary, and shrubbery and flowers, the latter massed against a temporary wall which had been erected on one side of the terrace or intertwined in trellises about the other three sides. Every service table bore a large bouquet of roses, and it should be said that the luncheon was admirably served, without crowding, although it was estimated that there was an attendance of 600 people. Music on the lawn was supplied by the well-known Reeves American Band of Providence, and later in the evening an orchestra in the main hall of the club supplied music for dancing.

Throughout the evening members gathered in groups about the verandas or on the lawn and enjoyed to the utmost the opportunity for a social time, and were unanimous in saying that it was one of the most successful social events they had ever attended.

Entertainment for the Ladies

Wednesday, the first full day of the meeting, was strictly a business day, with sessions morning, afternoon and evening. All-day entertainment, therefore, was provided for the ladies under the guidance of the Woman's Committee, of which Mrs. R. Sanford Riley was chairman, assisted by the wives of the Worcester membership. At ten o'clock in the morning automobiles left the Bancroft Hotel bearing the ladies to an interesting exhibit at the Crompton and Knowles Loom Works, where fancy looms were in operation. This was followed by a motor ride around Lake Quinsigamond and to Shrewsbury for a call at Iristhorpe, the summer home of Major and Mrs.



Main Street and City Hall, Characteristic of Worcester's Business Section

Homer Gage, where the visitors were afforded the opportunity to see the magnificent gardens and landscape architecture of the estate.

The plant of the Worcester Corset Company was the next stopping place. This is one of the model factories, not only of Worcester, but of the country. Although its main buildings were erected several years ago, its features, with respect to cleanliness, ventilation and general hygienic and attractive surroundings, are comparable to the best that is to be found anywhere. The guests were received by Mr. E. Seward, treasurer of the company, and lunch was served in the main dining room. Each table was decorated by flags of the allied nations, with a carnation at each cover. After lunch the guests inspected the factory and the specially arranged exhibit of the company's products.

The next event was the trip to the Tatnuck Country Club, where tea was served and the guests spent an hour in enjoyment of the club house and grounds. The interior was beautifully decorated by bouquets of rare flowers contributed by Mrs. Charles H. Morgan, wife of the late Charles H. Morgan, former president of the Society.

In the evening, during the professional session, a bridge party was arranged at the Bancroft in which many of the ladies participated.

Thursday was a patriotic day, symbolized by a visit to the famous Salisbury mansion, built by Stephen Salisbury in 1770 and now used as headquarters for the Red Cross. At noon the party was taken to the plants of the Norton Companies to join with the engineers at luncheon and in the inspection of the interesting features of the Norton Companies' plants.

The ladies who attended the Worcester meeting were most appreciative of the reception which they had received and the care and thought which had been displayed by the wives of the Worcester members in making their stay at Worcester so enjoyable.

ART MUSEUM WHERE RECEPTION WAS HELD ON TUESDAY EVENING

THE AUTOMOBILE TRIP ON FRIDAY

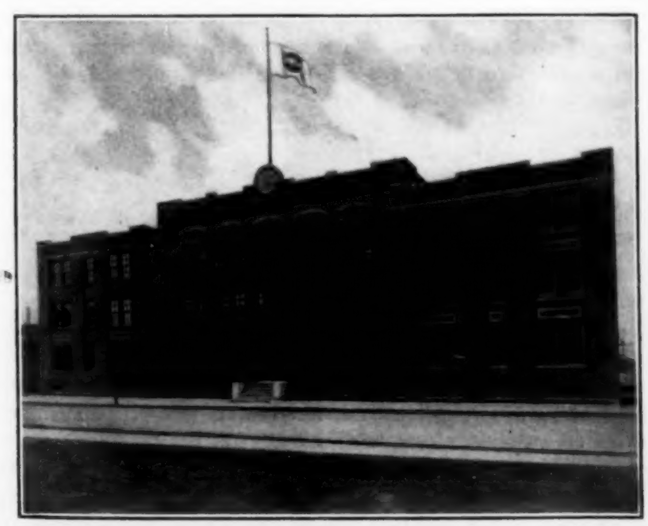
Members were warned to be on hand early on Friday morning to secure their assignment to cars for the all-day trip to Camp Devens, Lexington, Concord and the Wayside Inn. The guests were there and started on time, but shortly after it began to rain, and at times during the forenoon there was a downpour which resulted in some delay and difficulty in getting about when Camp Devens was reached.

The visitors were to witness an artillery exhibit, and about twenty cars reached the artillery grounds, but *fortunately*, rather than unfortunately, the others did not reach this point, for, owing to the muddy condition of the road leading to the field, it would have been difficult not only to have made the trip, but to arrange for the parking of the cars. Toward noon the showers abated while the company waited for lunch, and in the afternoon the skies cleared and the balance of the trip was made under ideal weather conditions.

Camp Devens was a revelation to many of the party, who realized what equipment was required for water supply, sewerage, heat, etc., in addition to the visible buildings.

Luncheon was served promptly at the appointed time in one of the dining halls, each person bearing his tray and being served in a manner akin to what might be devised by an expert scientific manager—an example that might well be studied by many who have attempted to conduct similar functions on a much smaller scale.

After continuing through Concord and Lexington most of the party returned by the way of the Wayside Inn, where tea was served and another delightful hour was spent in the inspection of this quaint and historic hostelry.



NORTON COMPANY'S ADMINISTRATION BUILDING, WHERE SESSION WAS HELD ON FRIDAY AFTERNOON

GENERAL AND LOCAL COMMITTEES

The professional sessions, as usual, were in charge of the Committee on Meetings of the Society, L. P. Alford, chairman. The chairmen of the local committees having the general direction of the convention were as follows:

General Committee, George I. Rockwood (Paul B. Morgan; vice-chairman, Howard P. Fairfield, secretary, William W. Bird, treasurer); *Reception*, John W. Higgins; *Women's Committee*, Mrs. R. Sanford Riley; *Hotel*, R. C. Cleveland; *Transportation*, James F. Healey (John P. Coghlin, vice-chairman); *Automobile*, John C. Harvey; *Finance*, William W. Bird; *Entertainment*, George N. Jeppson; *Printing and Publicity*, Howard W. Dunbar; *Chamber of Commerce*, Charles E. Hildreth.

Various sub-committees and individuals comprising the membership of the above committees were directly in charge of the several events of the meeting; and in fact the whole Worcester membership and their wives, and many other of the local people personally helped to make the meeting the great success that it was. Everyone in attendance was enthusiastic in his praise and pronounced the gathering one long to be remembered.

OPENING SESSION

On Tuesday evening the first gathering was held in the ballroom of Hotel Bancroft and constituted a reception to the visitors by the Worcester Chamber of Commerce, of which R. Sanford Riley, Mem.Am.Soc.M.E., is president. Mr. Riley greeted all present in behalf of the men of Worcester who make up the membership of the Chamber, saying in part:

"You will find our city interesting in many ways. First of all on account of its geographical situation. It is called a one-street town, because the main street runs along a valley with comparatively little level space at either side for cross streets. Our 200,000 population is strung out over a length of nearly nine miles. But the part of Worcester that is the most significant to engineers is the section parallel with Main Street where the industrial buildings stand. Mr. Washburn will speak later about the influence these early manufacturing buildings had in bringing to Worcester the infant industries which have now made the city famous.

"The ladies have even had to come to Worcester for such fundamental equipment as is required in the kitchen, for what kitchen is complete without some wire-goods device made from Worcester drawn wire. Machine shops all over the country send to us for their lathes, drills, grinding machines, planers and shapers. When one writes a letter he mails it in a Worcester-made envelope. Certainly the clothes one wears could not be woven without some of Worcester's looms. Shafting is driven by Worcester belts and trucks by Worcester chains. People travel in Worcester-built cars, both railroad and trolley. Every one has come in intimate contact with grinding wheels from Worcester because even if he does not require them for giant rolls or machine-shop work his dentist forces them on to you and into you where you feel them most. Our houses have Worcester rugs and carpets."

Mr. Riley referred to the splendid enthusiasm which Worcester had displayed in its campaigns for activities connected with the war and said this combination of coöperation and determination was its greatest asset. He hoped that the visitors would catch something of this spirit of Worcester. They had a very hearty welcome and a most cordial greeting from their friends of the city.

The chairman then introduced Mayor Pehr G. Holmes, who gave every one present assurance of the pleasure which the citizens of Worcester felt in welcoming a body such as that represented by the mechanical engineers who were in attendance.

President Charles T. Main, responding, presented the thanks of the Society to Worcester for its invitation to hold its convention in the city and for the hearty way in which the Society was received. He knew that the visiting members were in good hands with Dr. Ira N. Hollis, their past-president, as chairman of the Worcester Public Safety Committee.

Hon. Charles G. Washburn, president of the Worcester Polytechnic Institute Corporation and ex-congressman, gave an address on the Growth of an Industrial City, a report of which is here given. Following the address the members and guests were conveyed by automobile to the Worcester Art Museum, where a reception was held and an opportunity was given to view the remarkably fine collection of paintings, statuary and art objects. In close proximity to the Art Museum is the Worcester Woman's Club House, where, in Tuckerman Hall, beautifully decorated for the occasion, was held a dance.

THE DEVELOPMENT OF AN INDUSTRIAL CITY

By HON. CHARLES G. WASHBURN, WORCESTER, MASS.

I OWE it rather to the too favorable opinion of some of my friends in this Society than to any power of my own to either interest or instruct that I have the honor to address this distinguished audience this evening.

The Development of an Industrial City is the theme of my discourse; and, as this meeting is held in Worcester, it is very natural that I should confine myself to the development of industrial Worcester, typical, perhaps, of all New England communities of like character, excepting that no one industry has exclusively absorbed its energies.

The first record of any mill in Worcester is that of Capt. John Wing who had a saw and grist mill on Mill Brook, near Lincoln Square, in 1685.

The first manufactured product in Worcester was potash, made quite extensively in 1760. This gave the colonies an article of export with which to pay for manufactures imported from Great Britain. Isaiah Thomas manufactured paper here in 1785.

There was an increase in the variety of manufactures in Massachusetts early in the nineteenth century because of the embargo declared in December, 1807, and to the complications then existing between this country and France and England which led to an almost complete stoppage of importations, and manufactories of cotton goods, woolen goods, iron, glass, pottery and other articles rapidly sprang into existence. Some idea of the advancement of the world at this time from the engineering standpoint may be gained from the fact that the Academy of Science in France when consulted by Napoleon at the beginning of the century as to the steamboat spoke of it as a "mad idea, a gross error, an absurdity." When Fulton's first steamboat made the trip from New York to Albany in 1807, it happened to be the 17th of August, which caused many preachers to curse the machine on the ground that seventeen was the total of the horns and the seven heads of the beast of the Apocalypse.

Manufacturing Advantages

In 1823 attention was called to the advantages possessed by Worcester which should make it a large manufacturing center. Encouragement was found in the fact that towns in the interior of England, with no great local advantages, contained from 10,000 to 15,000 inhabitants, and that since the introduction of steam power, a population of from 80,000 to 100,000 had been reached. It was stated that Worcester would soon be at the head of canal navigation, and, in addition, her "inexhaustible store of anthracite coal, well calculated for steam engines," was referred to as being of the greatest value. There were deposits of coal here and a company was organized in 1829 to work them, but it was found to be too impure for economical use.

Peat, too, was found in the meadows about Worcester, and

in 1856 it was used to some extent as a substitute for wood and coal.

In June, 1827, Worcester is spoken of as containing "the largest paper mills, belonging to Elijah Burbank, five machine shops, at which great quantities of machinery of various kinds are made; one small cotton factory, a lead aqueduct factory and other works of minor note."

USE OF WATER POWER

Worcester, unlike many other manufacturing cities of New England, has always been without any great water power. Commenting upon this fact, a citizen of Worcester said some time before 1835, to Samuel Slater, who had mills in the adjoining town of Webster: "We shall never be a manufacturing town in Worcester because we have so little water power." Mr. Slater said in reply: "You may live to see the time when Worcester will need all the water of Mill Brook to provide the steam for her steam engines." While it is true that we have no great water power here, it is interesting, and I think to most people a rather surprising fact, that the small streams tributary to the Blackstone River have played a most important part in making possible manufacturing enterprises which have subsequently developed to a considerable size.

If I were asked to give the reasons for Worcester's growth in manufactures, I should mention as one of them the unusual opportunities offered to mechanics to begin business in a small way without incurring the risk incident upon the erection and equipment of a shop. Had this not been the case, many individual companies and corporations doing today a large business could never have started.

Many incidents might be given of individuals who have begun with one machine, gradually increasing their business until it has reached a considerable magnitude. Growth of this kind is likely to be permanent. It would be almost literally true to say that there is no large manufacturing business long established in Worcester that has not at some time in its history occupied one or another of the buildings erected for rent with power to a number of tenants. There are some exceptions, but they are few.

Another very important condition has been that of abundant transportation facilities, beginning in 1828, with the Blackstone canal, connecting Worcester and Providence, and followed by the railroads connecting Worcester with Boston in 1831, with Springfield in 1839, with Norwich in 1840, with Providence in 1847, with Nashua in 1848. It will thus be seen that from an early date Worcester had the advantage of the best railroad facilities existing at the time, which, with the introduction of steam power, made certain her rapid growth as a manufacturing city. Thirty years ago there was not only direct communication with all points north and south, but there were five outlets and thirteen different lines, more or less, affording direct communication with the West.

Of course, manufacturing here, as elsewhere, was dependent almost exclusively upon water or horse power until 1840. William A. Wheeler is said to have had a steam engine of some sort to run a fan in his foundry, but in 1831 or 1832 he abandoned this engine and substituted horse power, which he used until 1840, when he put in another engine. He is credited with having the first steam engine employed in the state west of Boston.

INDUSTRIAL GROWTH

It will obviously be impossible to treat in any detail the development of all of the manufacturing plants in Worcester. The story of each of them is full of romantic interest. I must content myself, however, with dealing with a few of them, typical, perhaps, of all. It is always interesting to know why a business is located where we happen to find it, and there is usually a good reason.

Among the most important industries in Worcester is the manufacture of machine tools. The founder of this industry here was named Samuel Flagg, or, as he was more familiarly known, "Uncle Sammy Flagg." He had a machine shop in West Boylston, a neighboring town, and moved to Worcester

HON. CHARLES G. WASHBURN

in 1839 in order that he might save the cartage of his castings to his machine shop in West Boylston, where he built tools and cotton machinery from patterns made by William A. Wheeler.

Mr. Flagg hired room and power in what was then known as Court Mills, built on that triangle of land bounded by Main, Union and Old Market Streets, and adjacent to Lincoln Square. He had no planer when he commenced; the work was done by hand chipping and filing. Court Mills was the cradle of the machine-tool industry in Worcester, and Mr. Flagg rocked the cradle. To his men and apprentices and to those who, in turn, served them, can be traced almost all of the concerns now engaged in this business.

MANUFACTURE OF LOOMS

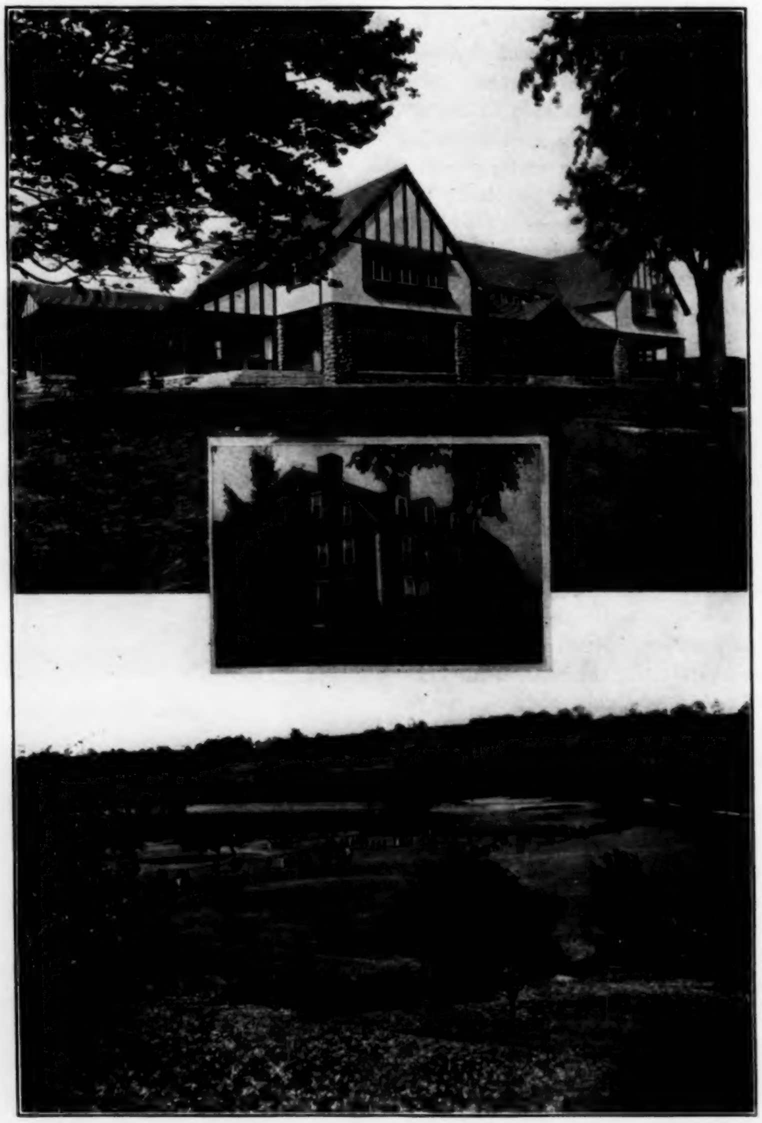
The manufacture of looms has for many years occupied a prominent place in Worcester, and it owes its location here to a very trivial circumstance. In 1836 William Crompton, then thirty years old, a native of Lancashire, England, came to Taunton, Mass., and went from there to Lowell at the request of the Middlesex Mills, where he applied his patented fancy harness motion, and, for the first time, wove fancy woolens by power. The late Samuel Davis soon after this happened to meet Mr. Crompton at a hotel in Boston. Mr. Crompton told him that he wanted to find someone to build his looms and expected to make a contract at Lowell. Mr. Davis suggested that Worcester would be a good place to build the looms. Mr. Crompton came here and made an arrangement with Messrs. Phelps and Bickford to build looms upon royalty. It was

in this way that the seed of the loom business was planted in Worcester.

In 1847 the late L. J. Knowles commenced the manufacture of cotton warp at Spencer, and subsequently was engaged in the manufacture of satinets in Warren. He made some improvement on the looms he was then running, and operated the germ of the mechanism of the fancy looms which were later built by his company, which moved to Worcester in 1866. In 1897 these two industries were consolidated under the names of Crompton and Knowles Loom Works with which the name of Worcester is associated the world over.

Perhaps I may be permitted to diverge at this point to consider for a moment the genealogy of business. Every manufacturing enterprise, like individuals, has ancestors and often descendants, although we know of some that have been childless. It is a very natural thing that the late George Crompton, a manufacturer of looms, should have become interested in developing a loom for weaving Brussels carpets by power. This led to the organization of The Crompton Carpet Company, of which M. J. Whittall was the superintendent. This association led to the subsequent absorption of the business by Mr. Whittall.

But this is not all; one of George Crompton's associates, and a man of great inventive capacity was Horace Wyman. His son, H. Winfield Wyman, and Wyman F. Gordon, a son of another of Mr. Crompton's associates, began in 1883 the manufacture of forgings for parts of looms, such as crankshafts, shuttle-box binders, and other forgings used in the manufacture of this class of machinery. That business has developed into the Wyman-Gordon Company, whose products are now known in every part of the country. It may truthfully be said that if Samuel Davis had not accidentally met William Crompton in Boston in 1840, the loom industry, carpet industry, and the Wyman-Gorden drop-forgings plant might never have existed here and the manufacturing aspect of the city would have been far different than at present.



WORCESTER COUNTRY CLUB, THE SCENE OF THURSDAY'S GARDEN PARTY. THE WAYSIDE INN IN THE CENTER, VISITED DURING THE AUTOMOBILE TRIP ON FRIDAY

THE WIRE BUSINESS

Perhaps Worcester is as closely associated with the development of the wire business as with any other. This was begun in Worcester in August, 1831, by Ichabod Washburn and Benjamin Goddard, on a small water privilege on what was known as Mill Brook, where they manufactured wire and wood screws. There is an interesting incident connected with the early history of the business which illustrates the great importance of comparatively trifling circumstances.

It seems that some time during the year 1831, Mr. Washburn, Mr. Goddard and General Heard visited North Providence, where three brothers by the name of Read were making wood screws. An arrangement was made with them and they moved their screw machinery to Worcester on a canal boat. The journey occupied three days. The business was conducted here under the patronage of Washburn and Goddard, at the Northville wire mill. At some time between April, 1836, and March, 1837, the screw business was moved back to Providence on a canal boat and ultimately became the nucleus of the Eagle, now the American Screw Company. Had the differences been adjusted — and they were probably trifling—the business of the American Screw Company might have been developed in Worcester rather than in Providence.

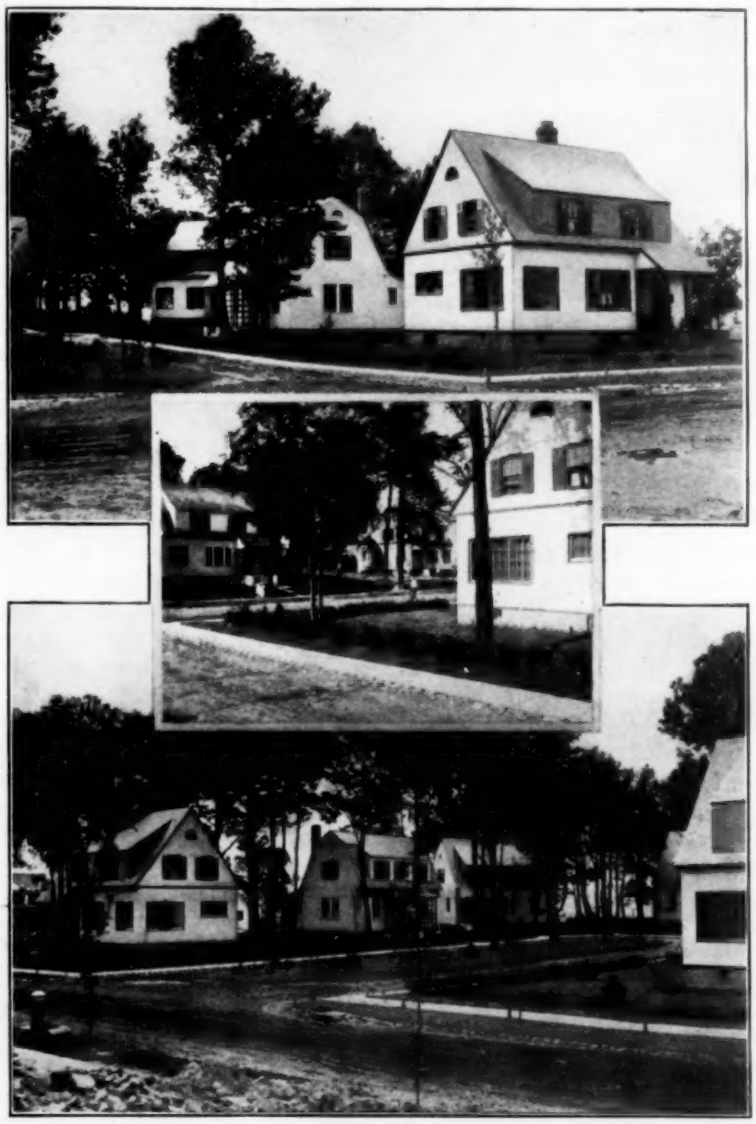
Washburn and Goddard also made card wire; indeed, the demand for card wire was probably the reason why the business started in this vicinity. The manufacture of cards was a very ancient industry. Tacks were first used in making hand cards, and the industry in the neighboring town of Leicester dates back to 1785. The card wire had been imported from England. From a report of Albert Gallatin, then Secretary of the Treasury, made in 1810, it appeared that the demand for cards was twice as much in 1809 as in 1808, and was increasing. Then this statement was made: "The wire is imported, and serious inconvenience would attend the stoppage of the supply, although the manufacture might and would be

immediately established to supply all demands if the same duty were laid on wire, now free, as on other articles of the same material."

In 1835 Ichabod Washburn moved to the fourth privilege on Mill Brook, the present location of the North Works of the American Steel and Wire Company. From 1837 until 1847 he purchased in Sweden his wire-rod billets. These were rolled into wire rods at Fall River, Troy and Windsor Locks, Conn., which were brought to Worcester to be drawn into wire. The inconvenience of having rolling done at a distance led Ichabod and his brother Charles, in 1847, to locate a rolling mill at Quinsigamond, the eighth privilege on Mill Brook, now the South Works of the American Steel and Wire Company.

The manufacture of music wire in 1850; the introduction of continuous tempering in 1856; the manufacture of crinoline wire in 1859; the introduction of continuous cleaning and galvanizing in 1860; the use of the continuous rolling mill in 1869, mark the conspicuous products and processes up to 1870.

The introduction of bessemer steel about 1876 created, as is well known, a revolution in the wire business, and furnished a better and cheaper material for many purposes, among them, and in the wire business chief among them, for the manufacture of barbed wire.



Views in the Indian Hill Community of Employees' Model Homes, Developed by the Norton Company—A Point of Attraction for the Visitors on Thursday

Factor in City's Growth

In the spring of 1876, upon the urgent advice of Charles F. Washburn, an officer of the company, who believed that the introduction of barbed wire would solve the fencing problem for the farmers of the West, the Washburn-Moen Manufacturing Company caused automatic machinery to be constructed and patented, and in conjunction with Isaac L. Ellwood of DeKalb, Ill., acquired control of the underlying barbed-wire patents. The amount of barbed wire manufactured in the country increased from five tons in 1874 to about 150,000 tons in 1888. Its effect upon the business of the Washburn and Moen Company may be measured by an increase in the number of operatives from 700 in 1875 to 2100 in 1889.

Among the first experiments with the telephone were those at the Washburn and Moen Works. A memorandum found among the papers of the late Charles F. Washburn states that the first experiments in talking through a telephone wire on the premises of the Washburn and Moen Manufacturing Company were in the month of March, 1876, with No. 20 bright iron wire laid on the floors of all the rooms in the lower story, from the rolling mills into the office of Charles H. Morgan, superintendent, at 94 Grove Street. The Washburn and Moen Company were large manufacturers of bale ties for binding hay, of copper wire, of wire rope, wire nails, and of insulated wire and cables, all of which greatly contributed to the growth of the business, and of the community. This business was acquired by the American Steel and Wire Company in 1899, which became one of the constituent companies of the United States Steel Corporation in 1901.

The Worcester Wire Company, the Spencer Wire Company, the Wright Wire Company, and several wire-working plants, have all greatly stimulated Worcester's growth.

It was natural that Charles H. Morgan, Past - President, Am. Soc.M.E., who, while general superintendent of the Washburn and Moen Manufacturing Company, had devoted much time to the construction of mills for rolling wire rods, should have continued in that field after he left the service of the corporation. He organized the Morgan Construction Company in 1891, to build metal-working machinery.

Wire rods have always been rolled in this country upon two distinct types of mills, the "Garrett Mill" and the "Morgan Continuous Mill." The latter has gradually displaced the former. The first continuous mill in this country was the one I have referred to, built in the fall of 1869 by the Washburn and Moen Company, and, in its essential features, an English invention. These continuous mills now produce an average of 400 tons a day of No. 5 wire rods.

By way of comparison, it may be interesting to state that in 1853 the capacity of the rolling mill at Quinsigamond was six

CAMP DEVENS, NEAR AYER, MASS., VISITED BY THE MEMBERS AND THEIR GUESTS ON FRIDAY OF THE SPRING MEETING. THIS VISIT NEW ENGLAND CANTONMENT WAS AN EXHIBITION OF ENGINEERING AND CONTRACTING SKILL, CONSTRUCTED AS IT WAS IN TEN

long tons a day of 10 hours. The automatic reels known as the laying and pouring type, now in universal use throughout the world and absolutely essential to a large tonnage, were invented by Charles H. Morgan and Fred H. Daniels, while they were with the Washburn and Moen Company.

Other Great Industries

Worcester has taken a foremost place in the development of the manufacture of machine-made envelopes. The third United States patent on a machine for making envelopes was issued to Dr. Russell L. Hawes of this city in 1853. This was the first successful machine in the country. Arnold, Rheutan, and the Messrs. Swift, made their contributions to the development of envelope-producing machinery. The three largest plants here were absorbed in the United States Envelope Company in 1898. Besides these, several independent plants are in operation, all contributing to give Worcester a conspicuous place in this industry.

In 1875, F. B. Norton had a pottery in a small wooden building on Water Street, where, in 1879, he began the manufacture of grinding wheels by the vitrified process. Since that time the production of these wheels has far outstripped that of any other kind and grinding has taken a large and revolutionizing place in many lines of manufacture.

The Norton Emery Wheel Company was incorporated in 1885. Two of the prime movers in the development of this business were Milton P. Higgins, then superintendent of the Washburn shops of the Polytechnic Institute, and George I. Alden, then professor of mechanical engineering. Both of them have been vice-presidents of this Society. In 1886 the Norton Company erected new works at the present location at Barbers Crossing. Of the marvelous development of the business of this company I need say nothing. You have seen the plant. But if you would keep pace with the growth, you must see it every day.

When I last inquired in March, 1917, they had over 3500 employees engaged in the manufacture of grinding wheels and other abrasive products and 850 engaged in the manufacture of grinding machines. But the story is not yet told. This company has been among the pioneers in establishing free medical service and a system of medical supervision of its employees, has provided homes for them in what is now a most extensive and attractive community, has supplied them with garden plots, has an agricultural society and an annual fair. This company not only makes a tremendous contribution to the material prosperity of Worcester, but to its fame as well. Mr. Higgins was a strong believer in giving students in mechanical engineering part of their training in a commercial shop. He had administered this system when he was superintendent of the Washburn shops of our Polytechnic Institute. He became a strong advocate of this half-time school and read a paper on this subject before the Society in 1899. Mr. Higgins subsequently was instrumental in securing legislation which provided that any city or town might establish an independent industrial school, the state and city or town to share equally in the cost of maintenance. He later became chairman of the first board of trustees of the Worcester Trade School.

I must resist the temptation to speak in any detail of the numerous industries not already mentioned that have contributed much to Worcester's growth and prosperity, of the manufacture of textile machinery, of the manufacture of card clothing begun here over seventy-five years ago, a business with which the name of Earle was associated for over one hundred years; of the manufacture of wool spinning machinery, once a prosperous but now a decadent industry because of the tremendous growth of the manufacture of worsteds; of the manufacture of thread, and of twisting machinery; of the foundries; of agricultural implements and machinery; of wrenches with which the name of Coes has been associated since 1840; of the building of cars, begun here in 1833 by Osgood Bradley, now under the management of the third generation of that surname; of the numerous manufacturers of woodworking machinery; of firearms, the manufacture of which by Ethan Allen was begun seventy years ago; of the Worcester Machine Screw Company, now one of the constituent companies of the Standard Screw Company; of the manufacture of steam engines, more extensive formerly than now; of the manufacture of boots and shoes, and of the manufacture of leather belting—one of Worcester's great industries.

Referring again to the genealogy of business, Isaac Goddard came to Worcester in 1812 and was apprenticed to Elijah Burbank at Quinsigamond to learn paper making. What more natural than that he should later begin to make paper machinery. The firm of Howe and Goddard became Goddard, Rice and Company, which, in turn, became Rice, Barton and Fales, the firm name for over forty years, and now in the management of the third generation of the Barton family. The J. R. Torry Razor Company, incorporated thirty-eight

Sanborn Photo Co.

WAS MADE THROUGH THE COURTESY OF SECRETARY OF WAR BAKER AND MAJOR GENERAL H. F. HODGES. THE BUILDING OF THIS WEEKS, AND CONSISTING OF 1500 BUILDINGS COVERING 10,000 ACRES AND HAVING A HOUSING CAPACITY FOR 43,000 SOLDIERS

years ago, was the first to successfully manufacture razors in the United States.

The Worcester Corset Company, to be visited by some of our guests during this convention, is a monument to the sagacity of D. H. Fanning. Sixty-one years ago the late Samuel Winslow ventured to make twenty-five pairs of skates, and in the first year sold nineteen pairs. The business still continues on a somewhat larger scale under the administration of his son.

The plunger elevator was designed nearly fifty years ago by Charles H. Morgan and Milton P. Higgins, and is still made here. The manufacture of cartridge belts, begun in 1880, has vastly increased because of present war conditions. The Worcester Pressed Steel Company, the Morgan Spring Company, the Heald Machine Company and the Allen-Higgins Wall Paper Company are all a part of Worcester's new industrial center—Barbers Crossing, created by the Norton Company.

In the short space of twelve years the Rockwood Sprinkler Company, product of the inventive genius of your associate, George I. Rockwood, Mem.Am.Soc.M.E., has sprung into national prominence as designer and installer of fire-sprinkler systems.

Such, my friends, is the brief story of the causes of Worcester's industrial growth, not unlike, I fancy, the growth of other industrial cities in New England. There is nothing spectacular about it. Indeed, judged by the standard of the modern industrial community created by the hand of the engineer almost over night, the development seems slow, covering, as it does, a period of eighty years, more or less, but if it has been slow, it has been sure, and the roots strike down deep. Most of those who laid the foundations were men of simple character who began life in a small way and made slow progress. They were reticent, modest, industrious, shrewd, enterprising and some of them very public spirited. They accumulated their property not always because of great gains, but more often because of frugal living and large savings.

BUSINESS MEETING

Amendments to the Constitution Adopted and Another Amendment Proposed; Five Committee Reports Presented; Address by Prof. O. Steels of Belgium; Tributes to Prof. Hutton

ON Wednesday morning, the members were taken by special cars from the Hotel Bancroft to the gymnasium of the Worcester Polytechnic Institute, where the Business Meeting and the first Professional Session were held.

President Main presided and in opening the meeting called for the result of the ballot by the membership on the amendments to the Constitution, which were first announced to the Society at the Spring Meeting of 1917 and were published in THE JOURNAL for October, 1917. The vote was as given below, and the President declared the amendments adopted.

Amendments	*Yes*	*No*
C 26	1110	20
45	1113	17
47	1116	14
55	1121	9
56	1124	6
58	1128	2

Next in order was the presentation and discussion of reports by special committees. Three of these were brief reports, presented by title, one by the Sub-Committee on Fire Protection, John R. Freeman, Chairman, on new tests of materials for fire prevention; one by the Committee on Steel Roller Chains, Prof. C. H. Benjamin, Chairman, constituting a progress report of this Committee; and a report by the Committee on Flanges and Pipe Fittings, of which the late John P. Sparrow was Chairman, constituting an addition to the 1914 American Standard for pipe fittings. This supplementary report covers heavy pressures up to 3000 lb. per sq. in.

REPORT ON SCREW-THREAD TOLERANCES

The next report was that of the Committee on Limits and Tolerances in Screw Thread Fits, Luther D. Burlingame Chairman, which is the result of several years' work of this Committee, during which not only was an extended investigation made of the subject, but a large number of taps and screws were measured, both for diameter and lead, and the

results tabulated to determine the present practice. A large number of gages were also distributed among manufacturers, which were tried out in their regular work to determine what could be considered commercial practice.

In presenting the report, Mr. Burlingame said that the proposition was such as might present itself to the individual who purchases taps in one part of the world, bolts and screws in another and nuts in another, from different manufacturers and at different times; and who desired to produce interchangeable work commercially, in distinction from precision work.

In taking up the matter, the Committee endeavored to weigh all the phases of the situation and naturally found many viewpoints, so that the report as finally worked out was in the nature of a compromise. The attempt had been made to put it in such a form that it could be used in the every-day shop in a practical way. The Committee had voted to present the matter as a tentative report in order to bring about discussion and to enable further steps to be taken, if necessary, to better adapt it to the purposes for which it was prepared. Since that time, a measure had been introduced into Congress and passed by the House (the Tilson Bill), calling for a commission to take up the whole matter of limits and tolerances of screw threads with the idea of having the authority and sanction of the Government back of whatever might be adopted. It was to be hoped that this bill would become a law.

After a general discussion, an adjournment by those interested was made to another room so that more time could be given to the subject than could be allowed during the regular business session. Since this discussion was primarily for the benefit of the Committee in its future consideration of the report, it is of interest only to a limited extent to the membership at large. It will be the purpose of The Journal, however, to touch upon its salient features when the report is later published in its pages.

Report of Committee on Weights and Measures

The last report to be presented was that of the Committee on Weights and Measures, of which Mr. Burlingame is also Chairman. It comprises an abstract of a report entitled the Metric System in Export Trade, by F. A. Halsey, of this Committee, based upon more than 1400 answers to a questionnaire sent to several thousand manufacturing firms in the United States. It was considered by the Committee that the resulting information was of such interest and value that the Society would be rendering real service if the essential facts, as deduced from the replies, were presented to the membership.

Samuel S. Dale, of Boston, opened the discussion by reporting the results of investigations made in South America by means of questionnaires issued by the Institute of Weights and Measures. He said these investigations show "that the metric system has caused confusion in South America instead of promoting uniformity. The people of Latin America, both Portuguese and Spanish, had a very good system which they are still using. The metric system, however, has been made compulsory by law, and to a certain extent they are using both systems; and in proportion to the extent to which they are using the metric system, the confusion has increased."

C. A. Briggs, of the Bureau of Standards, said that the subject should have a fairer discussion than appeared to be the case in the report, and he considered it unfortunate that it had come up at this time when the country was devoting its energies to the war. He declared that both the report and Mr. Halsey, its author, were biased and he was critical also of the American Institute of Weights and Measures which, while there was a great deal to do in relation to the subject of weights and measures, had devoted its energies to opposing the metric system.

He contended that the report was of value only if it were considered that foreign trade relations were satisfactory at the present time, but that the Government's interest in the matter was to increase export trade and our foreign trade relations. The question was how best to do this.

William Kent said he had heard the metric system discussed for 40 years and had noticed the unwillingness of advocates of the system to read the facts. In consequence, when metric advocates received a pamphlet like this from Mr. Halsey, it would go into the waste basket. They do not want anything of that kind. The thing to do is to try to get this report to the people who *will* read it. Here are hundreds of statements of facts and what is wanted are the facts.

L. P. Alford was in sympathy with Mr. Briggs in deprecating the expenditure of energy at the present time in the discussion of the metric system, when our efforts should all be in the direction of winning the war. He desired to point out, however, that the initiative which resulted in this report, was the report made in 1916 on the metric system in export trade, by the Bureau of Standards. In other words, this assemblage of facts is a reply to the previous report.

F. A. Halsey, in referring to the statement that the only activities of the Institute of Weights and Measures had been to combat the metric system, said he fully agreed that it was an unfortunate time to bring up the subject, but that they were defending themselves. They had a constructive program and had a great deal of work of a constructive character to do; but they had had no chance to take it up because they had to oppose the movement for the metric system.

With regard to the report of this Committee and the suggestion that it was biased, he said it was a statement of facts by others. He invited anyone to read the questionnaire as printed, and to judge for himself as to whether the questions were fair.

Proposed Amendment to the Constitution

On the initiative of the Council, Jesse M. Smith, Chairman of the Committee on Constitution and By-Laws, proposed an amendment to the Constitution to take the power of appointing the regular Nominating Committee out of the hands of the President and transfer it to the voting membership. The President stated that this proposed amendment was the most important that had come up for the Society in recent years. The proposed amendment was as follows:

"Strike out line 3 of C-47 which reads 'A Nominating Committee appointed by the President,' and insert the words 'Committees of' before 'Tellers' in line 4."

"Amend C 48 to read as follows:

"There shall be a Nominating Committee whose duty shall be to select candidates for the elective offices to be filled at each election. This Committee shall be elected annually by the voting membership of the Society. Other nominating committees having the same powers, may be constituted by the voting membership. The number of members, the election, organization and procedure of all Nominating Committees shall be as the By-Laws shall provide."

In proposing the amendment, Mr. Smith said that it embodied the fundamental principles and that the details of carrying out the election in any manner would be embodied in the By-Laws to be prepared later.

George I. Rockwood asked how the candidates were to be nominated, a question which led to a general discussion which was concluded by Louis C. Marburg of the Sections Committee, who confirmed what Mr. Smith had said and stated that the matter had been discussed by that Committee and a somewhat elaborate scheme worked out for a large Nominating Committee comprising delegates from the different Sections. The matter was brought before the Council and finally the point was raised that the Constitution should contain only fundamental ideas and that the details of appointing or selecting the Nominating Committee should be left to the By-Laws, which, however, could not become workable until the constitutional change was made.

Discussion Desired by Membership

On motion of Prof. Arthur M. Greene, Jr., the meeting voted to request a general discussion by the membership on the proposed amendment, with a view to publishing comments, and particularly adverse comments, if there are such. Communications on this subject are, therefore, solicited.

Engineering Council

Alfred D. Flinn, Secretary of the Engineering Council, was in attendance and gave a brief review of the organization of the Council and of the work which has developed under its direction during the past few months. The organization of the Council has already been fully presented to the readers of The Journal and the following summary of its committees will be of added interest:

Besides the usual standing committees is the American Engineering Service Committee, engaged in finding specialists for Government service, one of the recent requests being for men for submarine service and in response to which Mr. Flinn appealed to those in attendance at the meeting to send the Engineering Council the names of any graduates of technical schools under 35 years of age who might be ambitious for submarine service; the committee on Fuel Conservation is in coöperation with the Bureau of Mines and the U. S. Fuel Administrator; a recently established committee on Water Conservation through one of its members, Calvert Townley, recently presented a most valuable paper on the subject to the U. S. Chamber of Commerce; also, a committee on Industrial Affairs, which has been engaged in combating with other large organizations the so-called "anti-efficiency rider" in appropriation bills before Congress. Recently, the naval appropriation bill as finally passed indicated at least partial victory for the position which engineers are taking in permitting bonuses and similar rewards for additional or better work accomplished in the processes of production.

Arthur M. Greene, Jr., said that the Council of the Society at its meeting in Philadelphia recently, went on record as approving the action of the Engineering Council and believed it was its intention to have notification to this effect sent to Washington. He therefore introduced the following resolutions which were approved unanimously by the meeting:

"Whereas, It has come to the attention of the Spring Meeting of The American Society of Mechanical Engineers that the Engineering Council has sent a communication to Washington protesting against the riders to the appropriation bills preventing the use of money for work where time studies are made and where bonus is to be paid for work, and that this protest has been approved by the Council of The American Society of Mechanical Engineers; and

"Whereas, It is the opinion of this Society that accuracy and speed of production are important factors for the successful prosecution of the war, and, as engineers, we think time studies and bonus systems will aid in the increase of production and accuracy;

"Be It Resolved, The membership of this Society at its semi-annual meeting held in Worcester, Massachusetts, June 5, 1918, approve of the resolutions of the Engineering Council and respectfully request the President of the United States and both Houses of Congress to give careful consideration to the disastrous effects of these riders to the proper amount of production of material for our men at the front."

The resolutions were immediately wired to President Wilson, to the President *pro tem.* of the Senate, and to the Speaker of the House, and have since been acknowledged.

Telegrams were read, one from Col. John J. Carty of the Signal Corps and one from John D. Ryan, Chief of the Aircraft Production Board, asking for names of engineers to enter the service, one for a man to undertake the management of a large Signal Corps shop and the other for men who could in any way assist in aircraft production. These are indicative of the many calls which are coming to the Society for specialists in different fields which, to a large extent, have been successfully taken care of by its employment department.

Remarks by Prof. O. Steels

Prof. O. Steels, of the University of Ghent and the head of the Belgian Mission on Industrial Management, then gave a brief address, expressing his appreciation of the Society's assistance to the Mission. The industrial energy of Belgium is still great even in the face of the destruction of most of its sources, and will need the special impetus of scientific organization and management. This Mission represents the Belgian Government's study and preparation of steps toward starting industry after the war.

Some idea of the magnitude of the task of reconstruction to which the Mission looks forward was obtained from Professor Steels' brief review of the country's activities.

Only 30 per cent of the population (7,500,000 in 1910) was engaged in agriculture but the culture was so intensive that the yield was $2,000,000 per year. Horse breeding was one of the best-known activities, resulting in an annual export of 1400 horses a year to the United States. Horticulture was also important, amounting to an export trade of $500,000 worth of products to this country each year.

Besides those principal enterprises, Belgium is rich in some of the natural resources. The coal mines are deep and were operated to yield about 23,500,000 tons a year. A new and important coal region was discovered a few years ago and steps had been taken toward working it. It is presumed that many of those pits are now operated under German rule.

In 1911, twenty-five steel works, employing 18,000 workmen, produced 2,200,000 tons of iron and steel and 1,650,000 tons of finished steel products were turned out by the rolling mills. The earliest developments of the steel industry were first perfected in Liège and its vicinity. Near Liège, too, the zinc industry was a flourishing one, producing about one-quarter of the world's output of that commodity. Machine shops, locomotive works and similar industries were well developed.

Flanders was especially given over to the textile industry where there were about 1,200,000 spindles at work. Some wool and jute were also produced in that region. The glass industry—both ordinary and plate glass—was world-known. In harbor facilities, Antwerp was one of the first commercial ports of Europe, renowned for its world trade.

In closing, Professor Steels spoke feelingly of the military achievements of his country: "From the first days of August 1914 our army headed by our King has been in the field, and is still in the trenches doing its bit to stem the German onslaught. King Albert and Queen Elizabeth have lived with their soldiers during these four last years, sharing every day their dangers and their sufferings."

Tributes to the Late Frederick R. Hutton

As a fitting close to the Business Meeting, the President spoke briefly of the late Frederick R. Hutton, Honorary Secretary of the Society, who, more than any other member, had been closely associated with the activities of the Society. He said he had appointed a committee to prepare a memorial of Dr. Hutton, which would be presented at the next Annual Meeting in December.

Past-President Worcester R. Warner added a few words of appreciation, saying: "Professor Hutton is the one in the estimation of the older members who did more than any one else for the upbuilding of this Society, for making us acquainted with each other, for making the meetings pleasant for us as well as happy and agreeable in every way. When he first became our Secretary the membership was not made up of the type of men I see before me today. There were very few college men among the early membership of this Society, and that made it all the more difficult for the Secretary, who was a scholar and a master of English, to get along and endure our poor English. He used to translate my papers and my reports into English, and I believe it was an important part of his work to see that we made as creditable a record and report as possible. I used to thank him for it, which I have no doubt others of you here have done, and I told him years ago I wondered at the patience he had with us. And so we all remember him with the greatest pleasure and reverence. I mentioned to some of our members a little while ago the excellent resolution which he prepared expressing our thanks to the British Institution when they entertained us some eight years ago. I wish the members would read it;[1] it reads like Emerson or some of the other masters of English; and there were in those early days comparatively few masters of English in this Society."

William Kent also added a few words in which he referred to a remark made by Professor Hutton in reference to Mr. Holloway, one of the early Presidents of the Society, to the effect that his memory of Mr. Holloway was particularly of the treatment he received from him when a young man visiting the Lake Erie Engineering Works in Cleveland; that Holloway endeared himself to all the young men by treating them so kindly, giving them every facility to see his works and to talk with him and to have a good time with him. "That was Hutton's opinion of Holloway; that is my opinion of Hutton. Hutton did the same thing. Hutton's fond memory of Holloway was the treatment he received from Holloway. Our memory of Hutton is the treatment we received from Hutton. We know what joy it was to Hutton to have the memory of those who had been good to him; may it be an inspiration to the younger men who knew Hutton more recently to remember that that is the kind of man he was and that is the kind of men they should be—whose joy it is to help their fellow men."

NEW ENGLAND DAY SESSIONS

When the program for the Spring Meeting was arranged by the Committee on Meetings, it was planned to have the sessions on one day comprise papers contributed by engineers in Worcester and other New England cities, and this program was carried out with the following contributions relating to New England industries:

The Small Industry in a Democracy, George H. Haynes.

The Textile Industry in Relation to the War, J. E. Rousmaniere.

Converting a Factory for Munitions Manufacture, John S. Holbrook.

Some Economic Aspects of Fire Protection Problems and Hazards in War Times, J. Donald Pryor and Frank V. Sackett.

Oil Fuel in New England Power Plants, Henry W. Ballou.

This session developed naturally from that of the evening before, at which Mr. Washburn spoke on the Industries of Worcester, so many of which began in a small way. Following this was the address on Wednesday morning by Prof. George H. Haynes, treating of the relations of the small industry to a democracy; and in turn were the papers on certain of the specific industries and problems that are now being considered by New England manufacturers.

The papers by Messrs. Pryor and Sackett and by Mr. Ballou appeared in The Journal for June, and in this number are abstracts of the addresses by Professor Haynes and Messrs. Rousmaniere and Holbrook.

At the opening of the meeting, Dr. Hollis brought a message to the membership on the need for the conservation of our resources and the coal situation, which is also reported.

ADDRESS OF DR. IRA N. HOLLIS

I have one message that I want to send back to all parts of the United States, to every Section and to every engineer who can be reached through this meeting. While we are sitting here talking about things that we hope will be to the benefit of our country, our boys are quietly going to register themselves for service. While we are sitting here, too, some of our sailors are losing their lives on the sea and our army is shedding its blood on the other side. We ought to carry back home a certain consecration to duty for those boys. After all, what is it they have gone to fight for? We call it for democracy—to make the world safe for democracy; but there is something far more fundamental than democracy in this world and that is the Ten Commandments. Our boys are going to the other side to bring back to us the influence of that most appealing figure in all history, far greater than the victors of nations, far more potent than emperors and crowned kings and the glories of democracy,—the influence of Him who died on the cross.

The important problem before us, at the present time, I contend, is essentially a fuel problem. In Massachusetts, we bid fair in the course of the next year to be at least 6,000,000

[1] Trans. vol. 32, 1910, p. 626.

tons short of the necessary supply of coal to carry on our industries. The only difference of opinion on the subject is whether it will be 6,000,000 or 10,000,000 tons. Mr. Storrow called together a number of engineers in Boston, representing all the different societies, and through their influence a committee of five or six was named to take charge in Massachusetts of the work of effecting this 6,000,000-ton reduction in the demand for coal. The committee appointed, it may be said, was made up of men entirely from this Society.

It is no small task to present this case in every place in the state, but I have agreed to do that, or to call on members of our Society who live in New England to help in doing it. The great appeal to men who live in New England is a moral appeal. It has never failed yet. Behind the conservation of coal is a larger question. I call it one of the great moralities before the American people—to be frugal in the resources that God Almighty has put here for us to use in the future. That is what we ought to think of when we go into the fuel question.

During the past year one of the great firms here in Worcester formed a conservation committee, made up of employees, who had the power to enforce a certain policy to effect economies upon the entire company. It amounted to establishing a fuel board in that plant and is what we ought to bring about in every concern in the state, so that the men will work together willingly to save fuel. They discovered, after having gone through the month of December on the old system, that during the months of January and February they saved 40 per cent of their coal by economies outside of the boiler and engine rooms. They did not direct their attention to reducing the amount of coal for a certain quantity of steam, but to the use of the steam power after it was handed over to mills that had no responsibility for producing it. Forty per cent saved, when it was within their power to have saved it any time in the last twenty years!

I want to place forcibly before you the absolute importance of taking up economies and savings within the establishments where they are to be effected. After all, this is largely a question of good common sense, as are the bulk of the problems in our profession. In any establishment it is a matter of good-will and coöperation shared by everybody from the apprentice to the highest officer in the place, so that every individual has the feeling that he, too, is making some contribution.

If we can only put that into our factories and into our homes and into this country, if you can only take that back home with you, our boys on the other side are safe and they will do their task with the smallest loss. I feel more strongly than anything else that the Almighty has decided this long, long ago: those win who deserve to win. In God's name let us deserve to win. [Great applause.]

THE SMALL INDUSTRY IN A DEMOCRACY

By GEORGE H. HAYNES,[1] WORCESTER, MASS.

THE purpose of this paper is to raise question as to some of the industrial implications of democracy,—democracy which in government is set before us as the goal worth all this outpouring of blood and of treasure, this world anguish.

A generation ago, Gen. Francis A. Walker, then the dominating figure among American economists, declared: "For one, though believing thoroughly, so far as politics are concerned, in a government of the people, by the people, for the people, I see nothing which indicates that, within any near future, industry is to become less despotic than it now is. The power of the master in production, 'the captain of industry,' has steadily increased throughout the present century."

Though describing industry as having become "despotic," in his Political Economy (1887) which for a decade became the standard text for American college students, General Walker did not think it essential to give a single paragraph to the corporation as a form of business organization, nor a page to the modern monopoly problem, and he made no mention of such a thing as a "trust." In the 30 years that have since passed, concentration and consolidation have gone forward at an unprecedented rate. The new era in industry may be admirably illustrated by examples from the tale told last evening by Mr. Washburn. Thus, the enterprise started by Ichabod Washburn becomes the Washburn and Moen Company. It next is absorbed by the American Steel and Wire Company, with many plants in Worcester and elsewhere. And presently that company becomes one of the many concerns, aggregating nearly 150 plants, consolidated into the United States Steel Corporation, with a capital stock of $1,100,-000,000. The net earnings of this greatest of American industrial corporations were $295,000,000 for the past calendar year, and it carries on its payroll some 200,000 employees.

There are those who see nothing of challenging inconsistency presented by the development of such an *imperium in imperio*, of such an autocratically controlled industrial army—the largest among many—in America, the leader of the world toward the goal of democracy in government. They see no incongruity in the fact that we compel the children of this host of workers to attend our public schools, and we urge the newcomers to become American citizens—at any rate, we are going to urge them to do so, from now on!—and we thrust the ballot into their hands, so that in our accepted democratic theory the vote of the newly naturalized Syrian or Polander or Croatian counts for as much as does the vote of Judge Gary himself in determining who shall be the chief executive of Gary, Indiana, or the chief executive of the state of Pennsylvania, or the chief executive of the United States of America. Yet that workman's vote or voice is not to be counted at all in determining matters as intimately concerning his own life as the conditions of his daily work or the amount of his daily wage. These matters are determined for him by the management constituted by the control of 51 per cent of the stock of the New Jersey corporation. Stock ownership by the workmen, to be sure, is encouraged by the United States Steel Corporation, as by many another far-sighted and progressive concern; yet it is safe to say that in not one large corporation in a hundred does the stock vote of the workmen amount to enough to qualify at all the essentially autocratic management of the enterprise.

Nor is the situation greatly bettered, so far as consistency with political democracy is concerned, if the workmen be organized so that collectively they may drive a hard bargain to enforce their own demands. It used to be said that Russia was governed by a despotism tempered by fear of assassination. In democratic America, today, there is many a great industry which is controlled by an autocracy tempered by

[1] Professor of Economics and Political Science, Worcester Polytechnic Institute.

fear of revolution among its workmen in the form of a strike or sabotage.

And yet how many of us have reached the point where we believe that democracy in industry is coming, and ought to come? A striking forecast has recently come from the man who was the first president of the United States Steel Corporation, who later became the head of the company that runs the largest armament plant in the world, yet who, at the present moment—his willing service commandeered by the Government—is at the head of our Emergency Fleet construction. Mr. Charles M. Schwab is reported as saying: "The time is near at hand when the men of the working class—the men without property—will control the destinies of the world. The Bolsheviki sentiment must be taken into consideration, and in the very near future we must look to the worker for a solution of the great economic questions now being considered. I am not one carelessly to turn over my belongings for the uplift of the nation, but I am one who has come to a belief that the worker will rule, and the sooner we realize this, the better it will be for our country and the world at large."

The essence of democracy, in its industrial implications, is not to be found in equality of size, or wealth, or strength. Such equality is neither desirable nor possible. The motto of democracy in industry should be that of Carnot's army of the French Revolution: "*Carrière ouverte aux talents.*"

We recognize that in a democracy the individual, however humble his station, has a right to life, liberty and the pursuit of happiness, a right to the protection of his health and safety, and to educational opportunities which shall give him a fair chance to develop according to his ability. And the war is teaching us, more plainly than we ever saw it before, that, on the other side, in a democracy the State has a right to expect from its citizens equality of sacrifice, in the sense that sacrifice shall be gaged according to their several abilities to bear burdens.

In a democracy, the industry—small as well as great—has its rights, entitled to careful safeguarding; and it has likewise its duties and special services, upon the rendering of which the very destiny of the State may depend.

Democracy is best held sane and secure against attack, if the field of enterprise is kept open for men with a capacity for leadership. At present in the United States there is little to be feared from the I. W. W. or Bolsheviki. But there is grave danger for the future if no heed is now paid to the causes producing these movements, and if the field of enterprise shall seem closed to all but those of wealth or "pull."

In the field of industry as in the field of government and on the field of battle, democracy is on trial. Every forward-looking man anticipates that the industrial testing of democracy after this war will be more severe than ever before. In its relations to industry democracy must develop efficiency equal to that of autocracy, else it is doomed to defeat. But efficiency in industry, as in war, is not alone a matter of training or equipment or centralized control,—it is a matter of the spirit, of morale. Events of the past few weeks have proved that the morale of liberty-loving citizen soldiery may offset in no small degree the superior training possessed by professional fighters. So whatever conduces to better morale in industry may more than counterbalance some other highly valued elements of efficiency. In two respects, as I shall attempt to show later, the small industry distinctively and strongly does conduce to better morale: (1) in the enthusiasm which it evokes in the ambitious young employer who is managing an enterprise which is his own; and (2) in the team play which is worked out between employer and workman.

Of course, democracy must find methods not inconsistent with its own spirit to get the greatest industrial enterprises accomplished. Democracy does not imply that in the twentieth century the dial is to be turned back and that giant industries are to be split up into small units, or that a limit is to be prescribed beyond which an industry must not expand.

Democracy does imply that industries, great and small, shall be given scope to develop their capabilities up to the point where their further expansion would hamper that of others, or would prove injurious to the public interest. A generation of fumbling efforts to work out the state's proper relation to industrial control has brought into recognition some things which 40 years ago were strangely blurred.

In the first place, we recognize far more clearly than when the Sherman Anti-Trust Law and the Interstate Commerce Law were enacted, that many industries are inherently monopolistic, and that any effort to force competition in them is doomed to failure and can result only in increased cost and lessened efficiency of service. In this broad field, public interest is best to be subserved either by private operation under thoroughgoing regulation, or by government ownership and operation. Right now, under stress of war, weighty experiments are being tried out, which will throw much light on the monopoly problem.

In the second place, it is now recognized that in the so-called "trust movement," where no element of genuine monopoly has been present, a large factor has been the desire to secure the economies of large-scale production. This is a sound and constructive motive, and democracy is concerned to have such economies attained, to the extent that does not interfere with some higher or more essential purpose.

In the third place, it is obvious that certain enterprises must be conducted on a giant scale, if at all. A copper-smelting plant, a sugar refinery, a powder plant, locomotive works, as such enterprises are now conducted, may well involve an initial investment running up into the millions. The scale most conducive to economical production is not to be predetermined by any rigid or general rule. It must be worked out in each industry and in each community according to the conditions which conduce to greatest efficiency. Each enterprise should have a fair chance for a start and for normal growth, according to the effectiveness which it develops.

Democracy craves variety and individuality in industrial development. It needs the small industry not less than the large. The point which I wish to emphasize is, not so much that in a democracy the individual enterpriser needs the help and protection of the state, as that the state needs the widely distributed initiative and enthusiasm of ambitious young enterprisers.

Democracy needs to avail itself of the varied industrial talent and aptitudes of the many, and not merely of the genius of the few. There is another and a more important concern here involved than that of getting a maximum output produced at minimum cost. It is the calling forth of widely diffused and varied industrial leadership. "The magic of private property turns sand into gold." It means much for the strength and stability of a democracy, if the man with capacity for industrial leadership finds scope for developing his aptitudes as his own master, in the enterprise of his own starting, and not as a foreman or as a member of the staff of some giant corporation. Right here lies a cardinal difference between industrial democracy as we would see it develop in the United States and the type of socialism which many fear. Is it not possible to keep open the door of opportunity and enable the young man to discover and develop his own aptitude, without at the same

time making him the servant of the state, subject to a repression no less galling because imposed at the behest of a majority?

In recent years there has developed a new and discriminating appreciation of certain advantages of the small plant in industries which are not inherently monopolistic or in which the economies of large-scale production are not a dominant consideration. Perhaps foremost among these advantages is that which relates to the element of *quality*. America has wrought her most distinctive miracles in quantity production. Ford automobiles, to take the most notable example, are turned out by the million. But during the past year we have had our illusions removed as to the speed with which the highest type of fighting aeroplanes can be produced. Where the craftsman skill and precision are needed, more trustworthy products can be secured in the small shop than in the mammoth plant. A second advantage is found in the direct and intimate relation between office and shop in the small plant. Here the workers are still *men*,—yes, individuals, even, in the thought and under the eye of the superintendent or employer, while he is a distinct and knowable personality. This has not a few important results. In the small shop decisions are transmitted from the proprietor-manager straight to the workmen, and are carried into effect at once. Said one of our Institute graduates, a few days ago: "During the past six months we have nearly doubled our output, but we've added only one man to our office force. That puts us all under a good deal of strain." "Why not put more men on your office staff?" I inquired. His reply was: "That would mean just so much more red-tape and complication. When I first went with the firm (less than ten years ago), there were in the office just Mr. A. (the inventor-proprietor), Mr. B., his partner, and one other man. *Then* things used to hum! But the more men you get in, the more cards and reports have to be made out, merely to insure *the same degree* of efficiency."

Leadership "carries" better in the small industry. The proprietor's personality and enthusiasm can lay hold upon 25 or 50 men, whereas to a force of 500 he would be simply "the boss." *Esprit de corps* and morale are of natural growth in the small shop; they are hard to develop and maintain where there is no human contact between the employer and the workmen, and where the workmen are not personally known to one another. In the small shop there can be brought home to the individual workman the direct interest which he has in maintaining both the quantity and the quality of the product; he can be brought to see clearly how his own work is discredited and his own wage lowered in consequence of the soldiering or waste of material by any member of the working force. It goes without saying that the mutual understanding between employer and employees in a small industry is a strong influence in lessening the frequency and the seriousness of labor controversies.

In fact, the advantages of the small shop are so obvious that in these days of giant corporations some of the most interesting and promising experiments in industrial management are in the attempts to reorganize production "on the small-shop basis," assigning to a superintendent and small force of men the making of a particular part or the completion of a certain series of processes in the turning out of the finished product.[1]

If it be granted that the small industry in many fields of production has distinct advantages, and that the easy and natural progress from able and ambitious workman to proprietor is accordant with the spirit of democracy and tends to safeguard it from developing industrial Bourbonism on the one hand, or industrial Bolshevikism on the other, the question presents itself: What chance has the small industry in the democracy of today? Is it getting a better or a poorer chance than a generation ago? To what extent and in what ways should a democracy, in its own interest, seek to insure that chance?

Here the first step, thoroughly in accord with the democratic principle, is to see to it that the field of opportunity is not narrowed by encroachments of monopoly not controlled in the public interest. Despite the contemptuous sniffing with which not a few self-styled "hard-headed business men" have referred to the "New Freedom" programme, I venture to believe that the spirit embodied in the Clayton Anti-Trust Law and the Federal Trade Commission Law is constructive and deserving of approval. Those laws attempt reasonable definition, where the Sherman Anti-Trust Law introduced sweeping prohibition which hastened the very development it was intended to curb. Experience has shown and doubtless will continue to show defects in these laws needing correction. But they merit a better spirit of coöperation than in many quarters they have received. The present moment in the world's history is a time more appropriate for sincere and thoroughgoing study of the ethics of business than for disdainful ridicule of any efforts to restrain unfair competition.

But many a small industry fails to "make good" not because of unfair practices on the part of rivals, nor from any lack of inventiveness, resourcefulness or managerial ability on the part of its enterpriser, but because he encountered exceptional difficulties in securing some one of the elements requisite to its success. If—as I believe—it is essential to the safety and stability of democracy itself that its life be constantly renewed by the upgrowth of small industries, by the direct progress of ambitious young workmen into the ranks of proprietors, what steps should a democracy take to remove obstacles to such progress and to insure to the small industry a reasonable chance to work out it own salvation?

"Paternalism!" someone exclaims, at the mere raising of that question. But to my mind "paternalism" conveys the idea of coddling a weakling, to make things easy for the pampered child. It seems misapplied when used with reference to government action for the assuring of equitable industrial conditions essential to the safety of democracy. Nevertheless, it must be acknowledged that that way danger lies. The history of the protective tariff affords enough illustrations of the possibility that government action, ostensibly in the public interest, may be so designed and carried into effect as in some instances to benefit the few at great cost to the many. That there is some liability to abuse is not to be denied. However, the motive here advanced is not that of fostering any particular enterprise but rather the giving to small industries a fair chance, in order that by their growth they may safeguard democracy by lessening the danger of the development of a basis for class consciousness.

I—Power

All industries here in view are users of power. The obvious implication of democracy—though it has secured but tardy recognition—is that nature's sources of power should be made generally serviceable to the community as a whole, and should not be exploited primarily for the profit of the favored few. This idea underlies the recent movement by

[1] See the Small Shop System, by Peter F. O'Shea. An interview with Mr. F. O. Wells, president of the Greenfield Tap and Die Corporation. This article is soon to appear in *Factory*.

the National Government and by several of the states for the survey of water powers and for their conservation in the interest of all the people.

Most of the modern electric-power enterprises have been built up and are controlled by private concerns; a large proportion of them, scattered the country over, are in the hands of a comparatively few corporations which specialize in such enterprises. They are, thus, in position to bring to bear the highest engineering skill upon the solution of all technical problems, and they possess certain marked advantages in relation to maintenance and management. Here democracy is confronted by the tremendous problem of the government's relation to such enterprises,—of government ownership, with its diverse political and economic implications. A number of cities have been trying experiments under varied enough conditions to make their results of considerable interest and significance. Without exception, so far as I have observed, they report a substantial reduction in the rate made by the private corporations—it was 40 per cent in Seattle—dating from the first serious agitation for a municipal plant.

It cannot be stated too strongly that a conclusive comparison of the service rendered a community by a municipal plant and by a private corporation in competition with it can be made only by an expert, on the basis of painstaking investigation. The power rates of municipal plants are attractively low. But it must be borne in mind that those rates are in a sense not economic but "political,"—rates lower than could be made by any corporation which had to pay taxes, or which could not have its deficits made up from public appropriations. Depreciation charges are likely to be figured differently in the accounting of municipal as compared with private corporations. There may be ample justification for the policy of the city's charging less than cost for electric power, just as for many years the Post Office Department was run with a view not to its paying expenses but to its rendering the maximum service in the development of the country. But if power rates are to be fixed on that basis, the policy ought to be frankly avowed. The question as to the comparative efficiency of service to be expected from a municipal plant as compared with that of a private corporation involves many considerations which cannot be reviewed in this brief paper.

Pacific Coast cities have been pioneers in selling electric power for manufacturing purposes. A comparison of their rates would involve a maze of complications entirely inappropriate in a paper of this character. A quotation from the power rate card of a single city may serve to indicate on what easy terms the starter of a small industry may there secure his power. In Los Angeles, California, the use of the aqueduct has made possible commercial power rates running from 4 cents per kw-hr. for the first 100 kw-hr. in any one month down to 1.05 cents for from 3000 to 6000 kw-hr. Pasadena generates power by a steam plant using fuel oil, and sells her customers electric power at just one-third what it cost at the time when the city plant was projected. In Seattle the rate has been reduced to about one-quarter of what it was under the old régime, and the city's hydroelectric works are being greatly extended. In Tacoma, the city has been selling power since 1897, but made no special effort along this line till 1912, when the rate was reduced from a uniform 3-cent rate to a sliding scale on which the price for kw-hr. according to the load factor runs from 24 cents (where the load factor is 10) to 0.45 cents (where the load factor is 100). And these rates are reduced by one-third where the customer agrees to take the power at certain hours and to cut off all or a large percentage of his power during the low-water period. Since 1912 there has been a marked increase in the use of electric power. Forty-two different types of industry appear upon the list of small users of power; they include machine shops, rubber factories, shipbuilding plants, meat packers, smelters, lumber manufacturers, etc. No one who reads the list can doubt that the Tacoma motor-rental system is serving effectively to diversify the city's industries, and to make it easy for an ambitious young workman to start an enterprise of his own.

A most timely document is the Report on Electric Power Supply in Great Britain (made public in December, 1917) by the Coal Conservation Sub-Committee of the British Ministry of Reconstruction. What lends especial interest to this report is the fact that, by way of enforcing the necessity for a most serious consideration of the recommendations which they present, they repeatedly refer to the disadvantages which the British manufacturer is sure to encounter in after-the-war competition with better-equipped American enterprises. For example:

> In the United States the amount of power per worker is 56 per cent more than in the United Kingdom—if we eliminate workers in trades where the use of power is limited, or even impossible, we shall probably find that in the U. S. A. the use of power, where it *can* be used, is nearly double what it is here. On the other hand, not only are the standard rates of wages higher in the U. S. A. but living conditions are better. There is little doubt that in the U. S. A. the average purchasing power of the individual is above what it is in this country, and that this is largely due to the more extensive use of power, which increases the individual's earning capacity. The best cure for low wages is more motive power. Or, from the manufacturer's point of view, the only offset against the increasing cost of labor is the more extensive use of motive power. Thus, the solution of the workman's problem, and also that of his employer, is the same, viz., the greatest possible use of power. Hence the growing importance of having available an adequate and cheap supply of power produced with the greatest economy of fuel. (p. 7.) The present coal consumption would, if used economically, produce at least three times the present amount of power.

The Committee makes the following recommendations: (pp. 1 and 17)

> The present inefficient system of over 600 districts should be superseded by a comprehensive system, in which Great Britain is divided into some sixteen districts, in each of which there should be one authority dealing with all the generation and *main* distribution.
>
> Sites suitable for electric generating purposes should at once be chosen where water is plentiful and transport facilities good or fuel close at hand.
>
> Each district of electrical supply under a single authority should be a large area, with the greatest possible variety of electrical requirements and including populous centers of industrial activity. Power available from surplus gas or waste heat should be turned into electrical energy on the spot in local plants which would feed into the main distribution system.

At a time when for many months it has been necessary to subject this country's fuel supply to rigid control, on a day when many of the gas and electric light companies in New England have but a week's supply ahead, when Worcester manufacturers are facing the prospect of having to close their shops or curtail production for months, and when the bins of probably half the householders of this city are empty of coal and when no assurance can be had of more than two-thirds of a winter's supply, I have ventured to refer to this radical proposal, put forth by an eminent and responsible group of investigators, for the conservation of England's coal supply, and for the most efficient development of power therefrom, in the interest of all her people.

II Capital

How shall a starting industry secure capital? In the days of Worcester's early industrial growth, the necessary capital units were small, and might be drawn from modest savings, or secured in considerable measure from personal acquaintances. But now the situation is vastly changed. The new industry is likely to need a greater amount of capital at the start, and its founder's acquaintances are less likely than three generations ago to have the requisite funds.

At the present time, some New England banks are paying considerable salaries to their representatives who go about in the community helping farmers decide how to invest borrowed capital most successfully in the development of their home farms, with the result that three parties gain: the bank, in securing a safe investment for its funds; the farmer, in getting capital, together with expert advice as to its intelligent use in his own farm problem; and the community, in securing a greatly increased production of food crops. Similar interest and coöperation may be shown by banks in the case of the starters of other small industries. Some modification of coöperative banking, as worked out in Germany and Switzerland, may enable men of character and enterprise to borrow upon their pooled credit, for the starting of a promising industry.

IV Labor

At the present time the "help" question is one of the most disheartening elements in the manufacturer's problem. Trade schools and vocational guidance are some of democracy's newer devices for affording the boy some training in fundamentals and for discovering to him and to his parents what his real aptitudes are. Public employment agencies may serve to bring employer and employee together and help distribute the labor force to the points where it is most needed. But the fundamental evil of the present situation lies far deeper. Ex-President Tucker, of Dartmouth College, declares that "the social curse of industrialism as it now exists lies in its effect upon the disposition and temper of industrial workers." He points out that by putting the worker under the dominance of the machine, by subjecting him to various conditions not of his own choosing, and by depriving him of the stimulus and incentive to private ownership, industrialism has alienated the man from his job; it has taken from him "the zest for work, than which nothing is more necessary to social progress."

One of America's most eminent engineers, Mr. Charles P. Steinmetz, has said that in every industrial enterprise there are three principal elements that need attention,—the financial, the technical and the human. He added that the I. W. W. put in their appearance where the human factor is neglected and to the employer who disregards that human factor his admonition is: "The I. W. W. will get you, if you don't watch out!"

Right here is one of the great advantages of the small industry and a prime element of its importance to a democracy. In the small shop, relations between employer and workmen still remain personal, human. The great corporations of the present day are striving earnestly to solve this problem of the human element. They are calling to their aid the psychologist and the sociologist; they engage trained experts as employment managers, and organize elaborate welfare departments. But no scientific organization for "hiring and firing" and no wholesale welfare work can duplicate the results in efficiency and *esprit de corps* of the working team which can be achieved by the employer in the small industry.

In a paper recently presented before this Society, Mr. Richard B. Gregg has discussed "What it costs to hire and fire." He intimated that an annual labor turnover of 20 per cent was not exceptional, and cited cases where for several successive years it had run as high as 45 per cent, while in one department of a certain cotton mill it had last year gone over 500 per cent. The losses which such incessant shifting involve to the employer, to the workman and his family and to the community are appalling. Yet every person here knows employers in small industries who through years have kept a loyal working force, relatively permanent and having an interest and a keen pride in "their" shop, and the quantity and quality of "their" product. It was such employers and such workmen as these who gave to this Worcester community its immensely strong and diversified industrial development, so hard to maintain under the changed conditions of today.

V Research

In one respect the small industry has been at an unnecessarily great disadvantage. The day of hit-or-miss or rule-of-thumb methods is clearly past. Yet the small industry cannot conduct scientific investigations in elaborately equipped and expensively manned research laboratories of its own. Here is a field where government, federal or state, may provide coöperation along lines similar to those of the U. S. Department of Agriculture and of the state experiment stations. The Bureau of Standards is already doing something in the way of research work for private concerns. The laboratories of this Institute, as of scores of engineering schools and universities, have facilities which may help solve the technical problems of many a small industry, at a fraction of the cost which would be involved if the manufacturer should attempt to have this work done in his own plant.

VI Publicity and Marketing

One of the greatest disadvantages under which the small industry labors is the difficulty in getting its product continuously and effectively before the public. Private enterprise has not failed to note this need and to provide well-designed facilities to meet it. For example, the Bush Terminal Company, not content with providing the splendid buildings in connection with which manufacturing space, power, light, heat, railway and shipping facilities are furnished to its tenants, has spent $2,000,000 to erect an "International Exhibit Building" at the very heart of the day-and-night activity of New York City, on West Forty-second Street. It is where every dealer would wish to have his show room, but could not afford to do so alone. This is genuine, scientific coöperative service on the part of a far-sighted corporation, and some small industries may find great advantage in availing themselves of this opportunity.

Considerable saving and enhanced efficiency could be secured if manufacturers in related lines would coöperate in their sales work. The automobile shows offer a spasmodic and spectacular example of what may be worked out in more simple and modest fashion in many lines of industry. The coöperative fruit-selling agencies of the Pacific Coast states and the produce-marketing organizations in other parts of the country present familiar illustrations of coöperative selling. Nor is this a matter unworthy of governmental interest and aid. The medieval fairs brought business and prosperity to the towns which held them. Even in war-stricken France, the past year, certain expositions have been maintained. Our own country affords illustrations of municipal industrial museums suggestive of a development which might be greatly extended, the

city providing ample and suitable halls and facilities for the display of the high-grade products distinctive of its industry,—doing this not as a matter of favoritism and patronage, but taking it upon itself to advance thereby the interests of the whole city as an industrial unit, in the spirit frequently shown by a progressive chamber of commerce.

An attempt has here been made to analyze some of democracy's implications in the industrial field, and to emphasize some aspects of the American industrial system which bid fair to subject our form of government to severe strain. Emphasis has been laid upon the small industry's consistency with the spirit of democracy, and its tendency to strengthen democratic institutions, and some ways have been suggested whereby through public or private coöperation the small industry, in the interest of democracy, may be given a better chance of success.

At any time these matters might have been considered of some academic interest; but right now they seem to me of a new and vital significance. I believe that it is an accurate forecast that in the future the historian will find the chief significance of this World War not in the dynastic and territorial changes which at present seem to us to be of such prodigious moment, but rather in the world-wide social and economic upheaval and revolution, for which the war is now preparing the way, and of which Russia affords a portentous example. Even before the outbreak of the war, in America as well as in Europe there were abundant signs that convulsion was impending.

The coming of peace will bring a period of tremendous readjustment. Back from the front will come scores of thousands of young officers, and millions of young soldiers, to be reassimilated into our economic and political life. That process will be vastly different from the readjustment which followed the Civil War. Back to our industrial centers these young men are to come, with a changed outlook upon life. Men who before the war had been plodding wage earners, hardly stepping outside their deep-worn rut from one year's end to another, and with no suspicion that life had anything else in store for them, have now seen other lands, other customs. They have had a great illumination. They have taken part in the greatest enterprise in the history of the human race. They have learned team play, and the immense effectiveness of disciplined coöperation. They have found within themselves unsuspected power to dare and to do and to lead. Let no one fancy that the return to the ranks of industry of these hosts of young crusaders, who have gone through hell to make the world a decent place to live in, will not add a tremendous ferment to the social and economic unrest. They are going to demand that democracy in government find its counterpart in democracy in industry; that life yield them something more than the day's wage,—that it give them something of the zest of adventure, of opportunity for advancement, of chance for independent leadership. Where shall these ambitions and restless energies find an outlet?

In the strain to which our institutions are sure to be subjected in the years that lie immediately before us, the small industry may render service of incalculable importance to American democracy. It offers scope for ambitious young men to rise from the ranks to positions of leadership. It keeps relations human between employer and workmen. It gives the lie to the class-conscious radical's assertion that America is divided into two hostile camps, the bourgeois and the proletariat. When the Allies shall have succeeded in making the world safe for democracy, the small industry may have no small part in making democracy safe for the world.

THE TEXTILE INDUSTRY IN RELATION TO THE WAR

BY J. E. ROUSMANIERE,[1] NEW YORK, N. Y.

I AM concerned with the selling of cotton goods. Before the war the firm with which I am connected sold to the Government a large amount of goods for the Army and Navy. We have, of course, sold them a much larger amount since the war has been on, and since I first went to Washington at the request of one of the representatives of the Government, to serve on a committee, I have given a rather large part of my time to helping the Government, so far as I could, to obtain the textiles of which they were in need, particularly cotton textiles, with which I am most familiar.

Those who have not looked into the matter carefully will be surprised at the need there is of textiles in all departments of the war-making machinery of the Government. In fact, it has been a theory of mine—which has not worked out in practice—that by reason of the lack of cotton and wool and rubber Germany's war-making ability would be restricted. But she is making war now probably better than she has in the past, and yet with the enormous use that is made of those three articles here, and on the theory that Germany has not received any for the past two years, it would seem as if she must get to the end of her rope.

Among the textiles used in war are cotton woven goods, woolen woven goods, cotton knit goods, woolen knit goods and same silk goods. There are four grades of woolen goods: overcoating, 32-oz.; suiting, 20-oz.; blanket, and woolen shirt. There are also various weights of cotton duck used for tentage and for wagon covers and the like. The cloth is used by the Government usually in the dyed state, but owing to the great need of haste they have been using large quantities in the gray state until the dyeing capacity of the country could be adjusted. There are also uniform cloths, fiber-dyed—that is, dyed in the cotton and then spun and woven, as used by the marine corps, or spun and then dyed, as used by the Army. There is also a silk material used in making cartridge bags, which, unlike cotton, does not leave any residue in the gun.

When the war began the Government did not have any stock of goods. There had been trouble with Mexico the summer before and practically all the stock of goods in the country had been taken by the Army and had been made up and used. The first time we went to Washington the Assistant Quartermaster General told us that he wanted 47,000,000 yd. of 12-oz. duck for tentage within nine months. There were three or four manufacturers present who made such goods, and we all agreed that 20,000,000 yd. could not be made in a year, much less 47,000,000 yd. in nine months. But the industry bestirred itself and is now supposed to be making 90,000,000 yd. per year, and has bettered the production which the Assistant Quartermaster General asked for a year ago last March. We all had commercial orders at that time to keep our looms busy, but in every case the man whose commercial business was interfered with has accepted the decision of the Government, and so far as my personal experience goes, the whole textile industry, both in the manufacturing and in the consuming end, has acknowledged the fact that the Government must be taken care of before anything else is done.

The same question has arisen within the last two months. When the drive across the water began and it was seen that the Army must be increased very rapidly, the buying that

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had been done on the established program at that time was found to be insufficient, and about the middle of April instructions came to us from the Government that we must deliver no more goods on our commercial orders of the class that is used in uniforms or for linings until the first of June, and for five or six weeks there were no goods delivered on commercial orders —the Government took them all.

In order that you may understand some of the needs of the Government for textiles, let me repeat a few of them, taken somewhat at random: The amount of woolen cloth needed for uniforms, for blankets and for overcoats for 3,000,000 men is enormous. A part of the wool used comes from Australia. Our Government went to the British Government, who had bought the entire clip in Australia, and obtained from them some of the wool, which in turn was doled out to the manufacturers who are to make woolen uniform cloth. One contract placed with one firm on woolen cloth at one time amounted to $57,000,000.

Then there are the cotton uniforms that are worn in summer; and the cotton uniform cloth required for 3,000,000 men is an enormous amount. Let me suggest some new demands which had not arisen before. One new use for wool that came up suddenly was occasioned by the demand for woolen puttees. United States soldiers had never worn puttees before and they do not wear them much now in this country, but it was found that the weather in the trenches, particularly in the winter, made the use of leggings impossible—that the men's legs became so cold that they could not stand it and they needed someing warm to wrap around them.

Immediately on war being declared the gas-mask question came up and the Government had to supply them for all the troops going across the water. It requires a very closely woven piece of fabric for the face cloth that contains the bull's-eyes, and heavy canvas for the pouch holding the aluminium container in which the chemical is placed and through which the air is sucked in through the rubber tube. These goods had to be gotten together quickly and mills had to go on to fabrics which they had never made before, but on the whole it has been done remarkably well. Now they also provide gas masks for horses.

One question that came before the committee early in the war grew out of the fact that the hospital corps required 500,000 suits of pajamas, necessitating about 3,000,000 yd. of goods. The Army hospital corps had always used pajamas, but in amounts requiring not over 100,000 yd. a year; and it so happened that they had adopted a standard which was a practical manufacturing proposition for only one mill. But the mill could not make 3,000,000 yd. as quickly as the Army needed it, and therefore a new pajama cloth had to be arranged for—a sort of chambray weave.

The Government has just purchased in the market 70,000,000 yd. of denim for overalls and jumpers and other purposes for the men in order to save their uniforms while they are working. The men who went abroad first were equipped with blue denims, but Pershing cabled back that blue denims were too conspicuous for the hostile aviators and therefore the Government had to change to the less conspicuous brown goods.

All of these problems have been solved by the industry and I think it is entitled to a very great deal of credit for the way in which it has adjusted its methods to the making of new cloths at short notice.

The amount of sheets and pillow cases needed for the hospitals was also large. The Government has lately placed an order for 240,000,000 yd. of bandage cloth for the Navy, for the Army, and for the Red Cross, consolidating the purchase.

The Navy also buys a very large amount of bleached twills for white uniforms. This is much the same cloth as the Army uniform cloth, but made a little wider and then bleached.

The use of heavy ducks by the Government is very large. I remember last fall at one time the General Staff in Washington received a requisition for 13,000,000 yd. of No. 4 duck, a very heavy material weighing almost a pound to a yard, and 22 in. wide, for use in tarpaulins. Another need of duck has lately arisen in the Emergency Fleet Corporation, which has just placed a large order which is needed promptly in order to complete the boats now being built at various shipyards.

Probably the greatest change was in the aeroplanes. Aeroplane wings had hitherto been made of linen, and while the practice was different in Italy, it had been the theory both in France and England that cotton cloth would not do for wings. Cotton has a tendency to expand and contract with the dryness and the dampness of the atmosphere, and it was also felt that cotton wings when shot by a shell would tear, whereas linen has very great tenacity and does not tear. But they experimented in many ways and developed a cloth made from specially treated cotton yarns. It is now said by the aeroplane service in Washington that that cotton cloth is standing up quite as well as the former linen. But it took a good deal of experimenting to convince the personnel that it would do as well as linen. However, so far as I know the battle planes are still equipped with linen cloth, a little of which we get through the British Government, but the practice planes and the slower planes are equipped with the cotton fabric.

Beyond these very large needs are those for covers for the 3-in. and the 6-in. and larger guns, which require a good deal of duck, taking it as a whole. And in addition a new belt had to be manufactured—a new apparatus to carry hand grenades—something that had not been used much by the Army before. Then there is the matter of truck covers; for one of the first orders of trucks over a million yards of goods was needed.

A large part of all these goods have been made in New England. The heavy ducks have been made in the South, but as many of the heavy duck mills in the South are owned and controlled in New England, they may be considered New England enterprises. Various of the mills in New Bedford are making the aeroplane and the balloon cloth. Fall River and other places are making the bandage cloth. The army duck is being made largely in Lowell and Manchester. The uniform cloth is being made very largely in Manchester, one concern turning out 500,000 yd. each week. The woolen cloths are made all over New England. And New England, taking into account its munition factories and its textile enterprises and others, seems to be doing its fair share and possibly more than territorially would be allotted to it in supplying the needs of the Government for carrying on the war.

As I said before, I feel that the textile industry as a whole has responded splendidly to the demands made by the Government. And I have no doubt but that these very industries have called on you for advice as to how they can make over their plants to manufacture the fabrics which the Government most needs, and increase their production—which is attempted in every plant in the country so far as labor conditions will permit. And I know that when such requests are made of you by the textile industry you will do everything that you can to help them meet what appears to be at first sight the overwhelming needs of the Government to supply its armed forces in all its branches. [Applause.]

CONVERTING A FACTORY FOR MUNITIONS MANUFACTURE

BY JOHN S. HOLBROOK,[1] PROVIDENCE, R. I.

THE Gorham Manufacturing Company, probably the largest silversmiths in the country, if not in the world, has been identified particularly with the sterling-silver trade. It has also made a considerable amount of silver-plated ware and of late years has produced a large quantity of bronze statuary, structural and ornamental bronze, besides various ecclesiastical wares such as pulpits, altar rails, chalices, etc., at its Elmwood plant in Providence, R. I. The step from this sort of work to the manufacture of metal goods for war munitions is consequently not as great as at first it might appear when we speak of silversmiths as munitions makers, for our men are trained in the handling of metals and in the use of machinery adapted to their manufacture—whether drafting, spinning, stamping, or casting, and we therefore were not handicapped as a strange concern might have been in the knowledge of metal handling.

Very shortly after the war broke out the Allied governments came to this country for munitions and we began to receive inquiries. Our superintendent at that time was Capt. O. V. Kean, a graduate of West Point and thoroughly familiar with ordnance work and the ordnance schools, and he naturally became interested in these inquiries.

The first negotiations entered into were with the British Government for 50,000,000 brass cups for small arms and the same number of cupro-nickel cups for Serbia, these being made in knuckle-joint presses which we already had on hand in our machine shop. The cupro-nickel cups were contracted for on April 14, 1915, and were delivered on time.

On May 11, 1915, we contracted for 50,000,000 brass cups to go with the cupro-nickel, but found our presses were too light to handle the heavier gage, which necessitated the purchase of new presses.

At the same time the French Government appeared in the market for cartridge cases for the 75-mm. gun, considered by many the most efficient weapon of the war. This was an entirely new proposition and involved a large expenditure both for new buildings and equipment, but after careful consideration the directors of the company felt that the contract was profitable and that as a matter of patriotic assistance to the Allied governments, with whom our sympathies even then were very strong, we should take the contract. They therefore authorized the building and equipment of a new one-story brick brass-case shop, 360 ft. 6 in. by 122 ft. 8 in., which has cost approximately $500,000.

The first contract with the French Government was for 500,000 of these 75-mm. cartridge cases, which upon completion was followed immediately by an order for 975,000 more. These orders were filled so satisfactorily that when we entered the war the French Government went out of their way to compliment our work to the United States Government.

The French Government contracts were followed by one from the Russian Government for 1,000,000 brass cases for 75-mm. high-explosive ammunition, and another from the Swiss Government for 200,000 75-mm. brass cartridge cases of a still different type. Later the Netherlands appeared in the market and gave us a contract for 1,000,000 lb. of brass disks for their small-arms cartridges, as well as for 340,000 lb. of cupro-nickel cups. Also the Danish and British Governments each placed orders for about 225,000 lb. of the latter, and smaller orders were filled for the Norwegian and Portuguese Governments. It should be stated that each of these contracts required a different cup, slightly different in gage, height, thickness of bottom, etc., and that special metal had to be carried for each contract.

These various contracts had fitted us with a broader experience and we had built up a reputation and were ready to begin serious work for the United States Government when we entered the war. At the same time we have been able to do some work for the Allied governments in addition to our United States Government work.

The first U. S. Army contract came March 30, 1917, even before war was declared, and was for small cups, 6,600,000 each of the brass and of the gilding metal, the latter being for the U. S. Army bullet jackets. In May, 1917, a contract was closed with the Maxims Munitions Corporation for 275,000,000 each of brass and cupro-nickel cups for Italy. The first order for cases was placed May 1, 1917, for the U. S. Navy 3-in. landing gun—again a different case from anything we had made before and requiring an entirely new outfit of tools but not machinery.

Immediately on the outbreak of the war our plant was placed at the command of the Government both as to its special war machinery and as to the silver plant. The Navy contract was followed by one in August for a large number of 3-in. cases for the U. S. Army—again a different case from that for the Navy landing gun, and French 75-mm. cases, the Army having decided to adopt that gun.

The Government then began to inquire what we could do on grenades, and after some negotiations we took no less than four separate orders for grenades, and at the request of the Government built an assembling and loading plant at a cost of considerably over $250,000, at East Providence. This plant is designed for an output of 100,000 loaded grenades per day. Ground was broken in December, 1917, and work started in the plant six weeks later.

Our contract for the Navy landing-gun case was so successfully filled that the Government asked us to make a large number of the large 4-in. 50-caliber cases. Another plant was required for this work, as it is done almost entirely by hydraulic presses, and after some negotiations the old plant of the Providence Machine Company on Eddy Street and Allen's Avenue was purchased, new buildings erected, the old buildings repaired, and the machinery installed, and they are just beginning production. The plant's ultimate capacity will be 2500 per day.

In December, 1917, the Army placed an additional order for the 75-mm. cases with the proviso that if we finished them by August 1, 1918, we should continue and make an additional million. More than one million have been delivered and we expect to complete the balance well in advance of the date specified.

Early in 1918 the Government took up with us the question of our assembling and machining the Stokes trench bomb. This involved a further outlay for machinery, but there was space enough in the Allen's Avenue plant and we accepted an order for these, deliveries of which have already begun. We anticipate turning out 1500 per day on our automatic machines and may considerably exceed this.

The machinery directly engaged on our munitions work and bought for that purpose has a capacity of between 25 and 30 millions of dollars' worth of output per year on the basis on which we now work, which is that the Government furnishes

[1] Vice-president, Gorham Manufacturing Company.

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the raw material and we the labor and assembling. Contracts actually in hand total something over a third of this amount—between 8 and 10 millions of dollars. This, however, does not take into consideration any machinery in the silver plant, and finding that we had capacity over and above our usual business, we have taken a considerable number of orders for miscellaneous equipment of various kinds. The disposition of the directors of the company is to place the plant as largely as possible on work which is directly useful to the Government and assist in every way in the successful prosecution of the war.

Special Equipment

With regard to the tools which the Gorham Manufacturing Company has found necessary in order to arrive at the stage of production which it has reached in this work, the following particulars may be of interest: The machinery and tools of the silver plant have in the main been totally inadequate and impractical for the munitions work. Certain knuckle-joint presses which we had been using in the machine shop of the silver plant were used for bullet cups, as mentioned in an earlier paragraph, but the brass small-arms cartridge cups came from stock so heavy that it broke down our presses and we had to order special presses from the E. W. Bliss Company.

The equipment for the brass-case shop consists approximately of 4 cupping presses, 2 indenting presses, 15 rack-and-pinion presses, 4 heading presses, 4 tapering presses and 33 Bullard lathes. There are also marking presses for stamping the heads of the cases with their identifying marks and lot numbers. The cupping presses (E. W. Bliss Co., No. 77½) are large presses for making the first cupping from the disk and are very powerful. The indenting presses were originally put in for work on the Russian and Swiss cases. As these are no longer made the presses are now used for cupping. The rack-and-pinion presses (E. W. Bliss Co., No. 66½) are presses which make the second, third and fourth draws of the French cases.

The annealing ovens consist of three large annealing furnaces and a number of mouth and body annealers. Most of the latter have been built by us and are so arranged that the case is turned around in a frame and at the end of a certain number of minutes is presented at the opening, where it is withdrawn by a man with a pair of pincers.

For the grenade plant we purchased 14 acres of land in East Providence from the Rumford Chemical Company and erected one-story frame buildings covered with asbestos shingles, all of a temporary character. These buildings consist of two assembly rooms connected with the loading plant by a covered passage, power house, loading plant, detonator assembly room, shipping and storage sheds, office building, and of course the usual accessory buildings such as toilets, rest room, etc., together with two magazines. We have also arranged with the New Haven road for a spur track into the property.

The plant at Eddy Street and Allen's Avenue is built on land having an area of about 100,000 sq. ft. Here it was found necessary to erect one new building as there was none with sufficient height to take the huge hydraulic presses, some of which require 40 ft. of headroom. These presses were obtained in various places and are of the following capacities:

2—250-ton, 1st draw	3— 150-ton, 5th draw
2—250-ton, 2d draw	4— 210-ton, 6th draw
2—250-ton, 3d draw	1— 90-ton, taper
3—200-ton, 4th draw	2— 100-ton, header

There are also such small presses for stamping, etc., as may be necessary, and ten lathes. All the presses mentioned above, with the exception of one, which was used in the Russian indenting and which was moved from the Elmwood plant, are hydraulic.

To manufacture the trench bombs we were also forced to buy new equipment, consisting mainly of automatic machinery. This included three large automatic lathes for the machining of the head of the bomb, and automatic machinery for making the boosters and other parts.

The Question of Employees

In connection with the East Providence plant it may be stated that we have large storage magazines buried in the woods two or three miles away from the plants, where a large part of the nitrated starch is carried. This material is transferred as required to smaller magazines at the plants and only a few hours' supply is carried on the premises. From the smaller magazines it is brought underground by a pneumatic conveyor.

As to employees, we have 25 to 30 trades represented in the silver shop and some of these employees are at work on war materials, a few having been transferred as the opportunity presented itself through the slowing down of the silver shop. Most of them, however, are at work in the silver shop in their regular rooms, working on such war materials as bomb sights, powder cans, ramrods, etc. Our highly skilled men, such as die sinkers, designers, etc., we have not been able to transfer to this war work. The chasers have been kept busy on their regular silver work as have also the designers. The die sinkers have been of help in making tools, but most of the tools are made in the machine shop.

At the present time there are over 3200 employees on the payroll, which means about $60,000 per week. The employees as a rule have stayed with the company and those transferred to the munitions work have been successfully trained under expert foremen acquainted with that kind of work. We found it necessary to add to the organization a number of expert men who had had previous experience in munitions manufacture and they are responsible for the training and upbuilding of the force.

The force of women employed has considerably more than doubled and it will be more than trebled by the time this paper is presented. The women employed in the Elmwood and Eddy Street plants are largely inspectors on brass cases and on parts of trench bombs and do not aggregate 100 altogether, whereas the number of women in the silver plant normally is in excess of 150. In the East Providence plant, or grenade plant, the women are in the majority, there being over 300 at present, which number will be increased to 500 to 600 when the plant is running at its full capacity. These girls are taken from the surrounding towns and are entirely untrained in the sort of work they are required to do. They assemble and load hand grenades, except as to certain processes which are entrusted to men. They are carefully selected and each one entering our employ has to be vouched for by at least two reputable citizens. We cannot afford to take any chances in a plant of this kind. The help is carefully picked and the inefficient ones rejected, this being shown by the large labor turnover—100 to 150 per week at the present time.

From the foregoing statements it will be seen that the problem of the Gorham Manufacturing Company has not been so much the transferring of present plant capacity and man power as it has been the building up of the new organization

to handle this work. The organization has been efficiently built up and its importance may be gaged by the fact that while the number of employees before the war was normally 1600 to 1800 at the Providence plant, it is at present about double that number, and all these new people have had to be brought in and trained. We have secured the help of able men, most of them acquainted with the production in their particular lines—some of them merely good machinists and mechanics. Of course this applies to the munitions only. We have found in the silver plant and bronze shop that our own foundrymen are able to handle any casting job which comes to us, and the munitions jobs which we have taken are far less complicated than the elaborate statuary moldings with which our molders are acquainted. The bronze-shop force, under the supervision of their foreman, has proved capable of handling such work as has come to them—ramrods, powder cans, thumb nuts, etc. An interesting part of this work is the work that is being done for the Government by means of our special process for depositing—on range finders and the like. We have had one or two contracts where very fine graduations were required and where the Government has found this process of great value for the reason that it might be depended upon to reproduce important parts absolutely without shrinkage.

FIRST GENERAL SESSION

THE first general session was held on Wednesday afternoon, June 5, in the Mechanical Engineering Building of the Worcester Polytechnic Institute. Vice-President Greene presided. The session was particularly well attended, and the discussion was keen, the first paper, entitled The Public Interest as the Bed Rock of Professional Practice, by Morris L. Cooke, ex-Manager of the Society, exciting so much interest that its discussion extended to half the proceedings of the session. This was to be anticipated from the nature of Mr. Cooke's paper, which, as the author frankly stated, was written for the purpose of determining what has been, and apparently continues to be, the attitude of engineering organizations toward society as expressed in their rules of conduct. Mr. Cooke's paper was one of the most important "policy" papers ever presented to the Society, and one which every member should take the time to read and discuss.

Mr. Cooke called attention to the inconsistency between the attitude of the engineers of the country toward the war—an attitude of spontaneous sacrifice—and their canons of professional practice as enunciated in the codes of ethics of their organizations. He thought this was a time to take stock and examine critically the orders under which society and its constituent elements are operated. Hence there can be no better time for a review of the regulations governing the professional practice of engineers. In this paper he sought to develop the engineer's concept of his public relationships and responsibilities as contrasted with such relatively minor obligations as those to the profession of engineering, to a client, to fellow-engineers, and to himself.

It seemed to him that the successful prosecution of the war was largely a question of our ability to keep it where President Wilson had placed it, on high moral ground. In a democracy this is not the work of one man, but of all the people. It is not our work purely as individuals, but it is our work in all our relationships, whether they be those of town life, church life, professional life, or what not. In these days of real peril, can we do less than write into our code that whatever our thought and practice may have been in the past, from this day forth it is unprofessional for an engineer to safeguard any private interest at the sacrifice of public welfare?

The chairman opened the paper for discussion, and Secretary Rice read a number of written contributions. In the first of these, by Charles M. Horton, the writer advocated rewriting our code by all means, but writing it in the spirit of what we shall do, and not what we shall not do. He thought the Society should "go big" at this thing and the members stand behind it to a man.

All the discussions which followed were in favor of Mr. Cooke's suggestion. All felt that engineers as useful and highly respected citizens should rewrite their codes in the spirit of the times, except one, Mr. Robert J. Hearne, who thought that if the present code were read as a whole, there was nothing in it that was directly antagonistic to the consideration of the public welfare by an engineer.

Secretary Rice opened the oral discussion by stating that he had been making the subject of this paper a religion in his administration of his office in the Society. He wanted to claim for engineers that they as individuals and idealists had contributed to the state of opinion in this country as to the object of this war, and the President has sensed these ideals of the nation and has phrased them.

He pleaded for a reconsecration of ourselves to the newer ideals, which he could express by no better phraseology at the moment than that recently expressed at the dedication of the Dayton Engineers' Club: "For the dissemination of truth and the promotion of civic righteousness."

L. P. Alford thought that a reframing of our code of ethics ought to be associated with a reframing of the statement of the aims and objects of the Society as expressed in the Constitution, and he presented a suitable resolution, which was carried.

Prof. W. W. Bird presented the second paper, on A Foundry Cost and Accounting System. This paper was developed as the result of experiments carried on in the commercial foundry at the Worcester Polytechnic Institute.

Professor Bird explained that the system was not a cost system, but was simply a signal system which could be kept up by the regular clerical force and which would give fairly accurate results of the profits from the foundry.

The system was based on the principle that the three most important items of cost are Core Labor, Molding Labor and Pounds of Castings Produced, and that each of the other items of cost was a function of one of these. Ledger accounts were opened for the three items, and by careful inventories at the beginning and end of each year the exact annual cost for each item was carried out.

Most of the criticisms of the system were to the effect that while it had been shown to apply to work of a very varied character, still the operations were fairly continuous. The discussers doubted whether the system would work so well for a foundry operated on different kinds of products.

Irving H. Cowdrey then presented a paper entitled Moisture Reabsorption of Air-Dried Douglas Fir and Hard Pine and the Effect on the Compressive Strengths. Though the interest in this paper was not so general, it was recognized that it embodied the results of an important research, which the

author presented in a remarkably clear and able manner. No discussion ensued.

The next paper was by Lieut. John L. Alden, entitled A High-Speed Air and Gas Washer. On account of the absence of the author, the paper was presented by title only. Three contributed discussions were read, by F. R. Still, W. H. Carrier and Henry P. Gale, respectively.

Briefly, the paper described a new type of washer, in which the entering dust-laden air is thoroughly wetted by the mist of the spray chamber, which removes much of the coarser dirt, and then is conducted through a helical conduit, where a large proportion of the remaining dust is thrown against the wet curved side of the washer, flowing off to the drain with the spent wash water. Due to high washing efficiency, only from 1 to 2 gal. of water are required per 1000 cu. ft. of air. Moreover, the apparatus is small, compact and of light weight, a 10,000-cu. ft. washer being but 5 ft. long and 5 ft. in diameter and weighing less than 400 lb.

That devices designed along the lines of the paper cannot be used in public buildings because of the noise they make was the criticism of Mr. Still, while Mr. Carrier considered that the principle described was not new, and varied hardly at all from the cyclone type of separator, provided with spray nozzles, which has long been used. Mr. Carrier considered the type as especially adapted for relatively small air quantities handled at high-fan pressures and where the air contains a great deal of coarse foreign material.

The last paper of the morning was presented to a small audience, but it nevertheless brought out interesting discussion and commanded attention. It was entitled An Investigation of the Uses of Steam in the Canning Factory, and was presented by Julian C. Smallwood. The paper was a unique one, in that it indicated the new types of mechanical-engineering problems confronting the special industries in war time. Heretofore there was not much mechanical engineering in canning—the essential consideration was the raw material, and no attention was paid to economy of operation in the process used. Now every attention was necessary. Members of the Society might take a lesson from this paper of Mr. Smallwood as illustrating new fields of application of their professional knowledge.

The paper described the various steam-using units in the canning factory, and suggested methods of increasing their efficiency, eliminating all avoidable wastes and utilizing all other wastes of heat as by-products.

Mr. W. D. Bigelow, of the National Canners' Association, supplemented the paper with a most interesting picture of some of the canners' problems, and pointed out the need for a publication which will give canners in general terms the essential facts of steam engineering as applied to the canning industry.

A. L. Webber spoke at length on his experiences in the sugar industry, especially with foaming materials. He gave some useful information on the velocity of circulation through evaporators.

L. B. McMillan called attention to simple ways in which the losses in canning apparatus could be reduced. B. H. Foster suggested the use of superheated steam to increase economy, and the author thought this was a possibility. Mr. Foster also thought that any attention which could be given to the conservation of fuel in canning plants at this time was commendable and worth the cost.

SAFETY EDUCATION SESSION

On Wednesday afternoon the session on Safety Education was held in the Salisbury Laboratories of the Polytechnic Institute, Vice-President C. H. Benjamin presiding. In opening the session, the chairman reviewed briefly the activities of the committees having charge of this educational work.

As a result of the interest of the officers of the National Safety Council and of the Workmen's Compensation Bureau, two committees were formed, the Committee of Eastern Universities, of which Prof. D. S. Kimball of Cornell University is chairman, and the Committee of Western Universities, of which Prof. Benjamin himself is chairman. He stated that the object of the committees was to stimulate educational work along safety lines and to interest the colleges and universities in it so that certain courses of instruction might be given in those institutions, and that the purpose of the present meeting was to contribute to that end. It was proposed further to furnish material, first in the form of lectures to be given by men eminent in the profession; second, in the nature of printed matter and of motion pictures, lantern slides, models, etc., for illustrative purposes, and thirdly, and most important, to formulate a brief system of education appropriate for this work.

Two papers were prepared for this session, one by L. A. De Blois on the Safety Engineer and one by George H. Follows on Safety and Welfare Work in the Engineer's Education.

Mr. De Blois' paper defines the field of the safety engineer and sets forth his goal as the reduction or elimination of accidents; it deals also with safety in construction, equipment and through supervision and education. Mr. Follows' paper takes up the question of safety as related to the engineer's education and outlines the commercial engineering course in the Carnegie Institute of Technology.

THE SAFETY ENGINEER

BY L. A. DE BLOIS,[1] WILMINGTON, DEL.

Seven years ago I visited the Gary Plant of the Illinois Steel Company, in the interests of reducing the number and severity of the industrial accidents occurring in the plants of the Du Pont Company. The United States Steel Corporation, of which the Gary Plant was a subsidiary, had even then established an enviable reputation for its work in accident prevention. The report of this visit, which is now a very painful one for me to read, briefly disposed of the subject by stating that accomplishments at Gary could be roughly divided into two classes: mechanical safeguarding, which was excellent, and safety advertising, which the writer believed was undertaken to convince the general public that the steel industry, with a reputation for innumerable serious accidents, was not so black as it had been painted.

As I reflect on these earlier impressions and realize that over a year passed before I fully appreciated the injustice I had done the work at Gary, I wonder how many engineers and executives think today as I thought then—that safety engineering is merely a matter of safeguarding and advertisement. Yet, if I were asked for an opinion, I would say without hesitation that the foreman and skilled laborer in our modern

[1] Safety Engineer, E. I. du Pont de Nemours and Company.

industries have a somewhat clearer conception of and entertain a more cordial feeling toward the safety movement than many engineers and executives. It is partly for this reason that I am anxious today to persuade those who have heretofore considered the "safety first" movement as a fad or a frill that safety engineering is true engineering, that freedom from accident hazards should be a fundamental requisite in the design of structures and machines and a rigid necessity in plant operation, and that the greatest obstacle in the path of such attainment exists in a certain apathy to the safety movement among engineers in general and in a very definite and lamentable scarcity of trained safety engineers technically fitted to carry forward the work.

Field of Safety Engineer Defined

Let us attempt to define the field of the safety engineer's activities. His goal is, of course, the reduction or elimination of accidents. Analysis of industrial accidents shows that from 15 to 25 per cent are unavoidable. In the Du Pont Company, which I am happy to represent, these are the cases which we attribute to "Risk of Employment," "Unknown Physical Deficiency," and "Act of God," and they may be passed by with the brief statement that the number is gradually decreasing as the general knowledge of accident prevention broadens. Of the remainder, or avoidable accidents, between 10 and 20 per cent are caused by unsafe mechanical or structural conditions and are therefore possible of correction. This leaves 80 to 90 per cent attributable to human defects, that is, to the shortcomings of the individual—ignorance, carelessness, irresponsibility, indifference, disobedience, recklessness, horseplay and inexperience of the injured or fellow-employee—and to defects of system such as lack of proper supervision, discipline, etc., in the organization.

Obviously, the safety engineer may not confine his attentions solely to the elimination of those accidents for which his employer or company could be judged responsible under the common law of master and servant; he seeks to eliminate all accidents regardless of responsibility. In 1916 there were approximately 22,000 persons killed in industrial accidents in this country alone and 500,000 injured to the extent of losing over four weeks from work. Such wastage of man-power and production is in the aggregate enormous and constitutes a monetary loss of serious proportions. Unfortunately, its dollars-and-cents equivalent cannot be readily estimated. Workmen's compensation acts, which have largely rendered unnecessary recourse to suits at common law, practically ignore the question of relative responsibility and place approximately one-half the burden of accident compensation for all accidents on the shoulders of the employer. In establishing a rate of compensation, however, these acts make no attempt to evaluate life and limb but, based somewhat on the average net judgments for damages in suits at common law, aim rather to fix on the industries a fair proportion of the financial burden. It is not reasonable, therefore, to assume that the cost of accidents to the people of any state is represented by the total annual payments for compensation. Losses incident to injury or death are in one sense no more compensable than losses by fire are "covered" by insurance. In both cases there has been withdrawn from the nation's reservoir man power, or property representing man power, which can never be replaced.

A remarkable thing about the preceding analysis of industrial accidents is that it seems to apply equally well to any industry. The Du Pont Company, for instance, engaged in the manufacture of the most dangerous materials used in both industry and war, discovers about the same assignment of responsibility for accidents as does the cement industry. Mining, railroads, and other industries have the same experience. Moreover, the non-fatal and fatal accident rates on the Du Pont Company's plants do not themselves differ greatly from the rates of other and so-called "non-hazardous" industries. Both premises lead us directly to the logical, though somewhat surprising, conclusion that neither the nature of the industry nor the character of the materials produced or handled has as much effect on the cause, frequency and severity of accidents as the safe design and equipment of plants, the provision of a proper organization and constant supervision and the education of the working force into habits of caution and careful practices.

Have we not in this way defined the field of the safety engineer's activities and accredited him to all the provinces of design, equipment, organization, supervision and education? His influence must surely spread into each of them if consistent accident prevention is to be attained. But in reality they cover practically the whole vast territory of industrial projection, construction and operation.

Safety in Construction

There may be some who would at first object radically to the intrusion of the safety engineer's ideas in all these matters, especially since, as the exponent of "safety first," he is sometimes accused of interference with production. Let us examine this from the practical side. In the design of structures no engineer neglects the safety factor—which has become one of the tools of his trade—but who has not encountered stairs poorly designed, or probably not designed at all but left to the experience of the carpenter, the handrails of which, put there for emergency, must be used continually if an accident is to be avoided? We are all acquainted with new plants where aisles are dangerously narrow, where there is insufficient headroom, where machinery is inaccessible for repairs and valves are difficult to get at for manipulation or repacking. The safety engineer who sees these conditions and recognizes that accidents will inevitably occur may be met with the objection that they have not yet caused accidents and that expensive alterations are not justified and would hold up operations. These matters could have been corrected at less expense in the original design, and probably would have been if any one with experience had considered them from this angle.

Safety in Equipment

As for equipment, there are types of machine tools that are dangerous and others that are less so and equally efficient—the cylindrical-head jointer, for instance; and there is machinery that could have been better safeguarded by the manufacturer if complete guarding had been specified or if the pressure of demand by the trade had forced him to recognize that he must supply adequate guards or suffer through unequal competition.

In the field of general mechanical safeguarding there has been marked progress in recent years and some excellent standards have been formulated, among them those of the A.S.M.E. But the more difficult problems encountered are those arising from local application and arrangement of machinery, often peculiar to the industry in question, and others due to conditions abnormal to regular operation. As a fundamental we may as well admit that no machinery can be made foolproof in

its regular operation, and we must furthermore admit that conditions occur during adjustment, oiling, cleaning, repairs, replacement, etc., under which standard safeguards may be useless or may even introduce hazard. Evidently the solution of the problem of how to make the equipment as safe as possible under all conditions cannot be reached through mere general acquaintance with machinery of the class in question, nor by a casual inspection of the plant in normal operation. The problem will yield only to analysis after a painstaking study of all phases of operation and of conditions such as poor lighting, inaccessibility and congestion which are contributory to accident.

Safety Through Supervising and Educating the Workers

I have already stated that the majority of accidents are due to the shortcomings of human nature, to personal tendencies and traits in the individuals liable to injury, and to deficiencies in the organization which employs, instructs, holds in restraint and disciplines them. Here the safety engineer is upon different ground and must employ his knowledge of psychology and the principles of industrial organization. His greatest aids will be diplomacy, perseverance, tact and patience with the slow response to his insistent efforts to change the mental viewpoint. But there is in this branch of the work a principle so important that its neglect will bring failure in place of success; it is a clear recognition of the fact that the safety engineer can no more effect general accident reduction by his own direct efforts alone than the doctor can make a healthy community by curing the sick.

Through general education we may awaken a sense of personal responsibility in the man and emphasize the fact that it is necessary to "be careful," but this injunction is of little value if the actual presence of danger is not realized. Failing these, we must rely on the detection of dangerous practices among the men. The safety inspector or safety engineer should be able to tell whether a certain practice is dangerous when he sees it, but he cannot watch all the practices of a thousand workingmen, or even a hundred. The one class of men who can perform this function most efficiently are the foremen, but some one must instruct the foremen as to what is dangerous. This is the function of the safety engineer or inspector. However, an executive authority immediately above the foreman must first convince him, and continue to convince him, that he is required to properly supervise for safety. The plant manager must place himself clearly on record to the effect that safety is as important in the day's work as production or quality, for it is from him that the organization takes its tone. From the directing officials of the company must come moral and financial support. Thus the whole organization is involved.

I trust that in the foregoing I have shown that safety engineering with its interests in design, equipment, organization, supervision and education should have a place in every field of industrial enterprise and that it bears as well a very definite and important relation to all other branches of engineering. This relation is so close and its need so urgent that I am convinced that some instruction in the fundamentals of safety engineering should be given a place in the training of every young engineer.

Value of the Safety Inspector

I do not wish to be understood as underrating the safety inspector. There are many among them who are successfully filling worthy and responsible positions. There are many more who bear about the same relation to the safety engineer as the stationary engineer does to the mechanical engineer. Many are capable of making thorough inspections and recommending standard safeguards but are debarred by personal limitations from going very much further. Yet in many plants nothing further is demanded. "We have a safety inspector and a safety committee"—the safety inspector of the "practical" type and the safety committee recruited from men in the shop who by some strange metamorphosis are expected to become suddenly expert in detecting hazards previously unrecognized. The real truth of the matter is that the safety committee proves very useful in detecting obvious conditions that the foremen and management ought to have observed and remedied long ago and the experience gained by the committeemen is good for them and opens their eyes to many common hazards.

Real Work for Real Engineers

The National Safety Council is the representative organization of the country dealing with safety. Since its foundation in 1912, its activities have extended until its membership now represents the employers of over 6,000,000 men. The safety of this vast army of workers should be in the hands of trained men, but there are few to fill the vacancies that exist today and the new positions that will be created tomorrow. It is not right that the onward march of the safety movement should be halted to permit its officers to be recruited and trained.

If there was ever need for a national campaign to reduce death and disablement from industrial accidents, that need is today. They tell us that at least three workers are necessary at home to supply one man at the front. By workers is meant producers—not hospital patients—and the war will bring us enough reconstruction problems in the employment of war cripples and returned soldiers without the problem of employing the many men crippled in our industries. Let us realize, then, that "safety" is not child's play, not a matter for "practical" men, not a passing fad, but real work for real engineers, and that the sooner we accept this viewpoint and shed our coats to the undertaking the less cause shall we have, when light comes, to regret the days of complacent inaction.

As Mr. Follows was not present at the meeting, Professor Benjamin called on Prof. J. A. Polson to read the paper in his absence, of which the following is an abstract:

SAFETY AND WELFARE WORK IN THE ENGINEER'S EDUCATION

By GEORGE H. FOLLOWS[1]

On March 2 of this year, at the American Museum of Safety, New York, under the auspices of the Committee on Safety Education of the National Safety Council, there was held a conference on safety education in technical schools and universities, with Mr. Albert W. Whitney, general manager of the National Workmen's Compensation Service Bureau, presiding. On March 20 a similar meeting was held in Chicago, with Mr. Whitney again the chair. At each of the meetings, a special committee was appointed to suggest ways and means of introducing definite courses of instruction in safety and welfare work in our engineering schools.

At the meeting in New York it was suggested that a corps

[1] Carnegie Institute of Technology, Pittsburgh.

Presented at the Spring Meeting, Worcester, Mass., June 4 to 7, 1918, of The American Society of Mechanical Engineers. The paper is here printed in abstract form. All papers are subject to revision.

of lecturers be chosen from among engineers of prominence in this field to visit the schools and give a series of safety talks to faculties, students and others. This suggestion was unanimously approved, but it was at the same time realized that although such a series, limited perhaps to three or four lectures at any one school, would undoubtedly arouse interest in the subject, it would not in itself constitute a definite course of instruction. To preach safety is one thing; to give efficient training in safety and welfare engineering is another. While keen interest was shown in the safety movement, the fear was rather generally expressed that it might be difficult to "find room" in any of the regular engineering courses for adequate treatment of the subject.

I was much impressed by what Mr. C. P. Tolman, chairman of the Manufacturing Committee of the National Lead Co., said at the New York meeting. In a most interesting and inspiring address he prophesied that within a very few years engineering schools would find it necessary to grant a special degree in safety and welfare engineering. He spoke of the wide field of usefulness of the safety engineer, of his value alike to employer and employee.

Practically every day since that meeting, I have been at work on a problem that the Carnegie Institute of Technology has been interested in for the past 11 years, the solution of which seems to provide the natural place for safety and welfare work in the engineering school. Our problem has been the course in commercial engineering.

I believe that in this course in commercial engineering there has been found the logical place for safety and welfare work; and this in my opinion is the crux of the problem, the realization that there is today a positive and increasing demand for a new type of engineer, and that the course of training which he must have naturally includes safety and welfare work.

The Carnegie Institute of Technology has chosen the name "Commercial" for this new type of engineer. At the outset let me say that his training must not be confused with that given in business colleges and schools of commerce; this in spite of the fact that some of the subjects handled will be found in these courses in business and commerce. The training of the commercial engineer must be based upon engineering science, economics, and psychology. Since 1907 Carnegie Tech has been giving definite courses of instruction and student work in economic production and works management, and a large proportion of the senior class in the several engineering fields has been scheduled for parts of these studies, which, however, have been specifically developed for the benefit of those graduating in commercial engineering.

If it is permissible to divide the entire range of engineering work into two main parts, the one technical, the other commercial, then the commercial engineer is the man who is trained to use or apply in a variety of ways but always efficiently what the technical engineer provides. And he is a distinct species, not a mechanical, electrical or any other kind of engineer who has in addition some other kind of general training, superficial in character, but a distinct species, whose entire college education and training are based upon the fundamentals of commercial engineering itself.

The field is broadly that of conservation, not only of materials and equipment, but of the time, the effort, the life, health and happiness of the men and women employed. There is a large and rapidly growing need for men who have been definitely trained in the direct solving of problems in this field.

Below is given the four-year schedule in commercial engineering as recently adopted by the faculty of Carnegie Tech. There was some opposition to the introduction of this as a schedule of studies leading to a bachelor of science degree in engineering, but it was finally adopted. As Mr. Whitney puts it: "Problems of industrial management are coming to be recognized as the great problems of the day." Who shall say that they may not be called engineering problems? If the designing of a milling machine is an engineering problem, surely the problems that confront, say, the efficiency man, or the safety and welfare man, are worthy of the same name! We must not forget what the word engineering means. We have no right to limit the use of it to material devices, no matter how ingenious they may be.

SCHEDULE OF COURSE IN COMMERCIAL ENGINEERING AT CARNEGIE INSTITUTE OF TECHNOLOGY

Freshmen

	F.	W.	S.
Mathematics	5-0	5-0	5-0
Chemistry	2-4	1-4	2-2
English	3-0	3-0	3-0
French	3-0	3-0	3-0
Drawing	1-3	0-3	0-3
Shop Processes		0-1	0-1

Sophomores

	F.	W.	S.
Mathematics	4-0	4-0	4-0
Physics	5-3		
Mechanics		4-0	3-0
French	3-0	3-0	
Economics	2-2	2-2	2-2
Psychology		1-2	2-0
Statistics		2-6	2-3
Accounting			0-4

Juniors

	F.	W.	S.
Materials	1-6		
Measurements	1-4		
Mechanical Laboratory		0-3	0-6
Prime Movers	2-0	2-0	
Machinery Analyses		1-3	2-3
Production Processes	1.0	1-0	2-0
Electricity and Magnetism			3-0
Commercial English			3-0
Commercial Illustrating	1-2	1-2	
Advanced Economics	1-0	1-0	1-0
Factory Costs	1-3	2-6	
Accounting	1-3	1-3	1-3
Commercial Law and Contracts		3-0	3-0

Seniors

	F.	W.	S.
Electrical Applications	2-3	2-3	2-3
Spanish	3-0	3-0	3-0
The Printery	1-3	1-3	
Banking and Insurance	2-3	2-3	
Transportation			2-3
Works Management	3-0		
Safety and Welfare Work		2-0	2-2
Economic Production	1-3	1-3	1-3
Buying and Selling	2-3	2-3	2-0
Industrial Corporations			3-2
Applied Psychology		2-0	1-2

In this schedule, F., W. and S. mean fall, winter and spring. The school year is divided into four quarters, with the three terms of regular scheduled work. The two-part figures, as 2-3, mean two hours of lecture or recitation and three hours of laboratory work per week.

During the past three months I have had repeated interviews with several well-known captains of industry in large engineering corporations, and they have been unanimous in

saying that today the field in commercial engineering offers greater opportunities to the young college graduate than any other single field of engineering work. One of these men put it in this way: "At present we have to take a mechanical or some other kind of engineer and instruct and train him along entirely new lines, lines of work of which he does not possess even the rudimentary fundamentals. It is a different kind of training altogether from that of the designer or strictly technical man. Men trained in the way you have outlined will be of immediate and great value to us." It is a significant fact that several of the large industrial corporations have already offered to employ our entire output of graduates in this new course.

A few years ago we experimented with what we called commercial options; and so we had electrical, civil, chemical, and mechanical commercials. We discovered that this hyphenating was inefficient. The idea itself was not unattractive to the orthodox engineering faculty, namely: that a man must be some kind of orthodox engineer first, and then if he chose he could be converted into a commercial engineer of sorts. In other words, he was to be a real engineer with the addition of commercial training.

It would be unreasonable at this time to go further into the details of the general course in commercial engineering. What I set out to show was that the course provides the logical place for safety and welfare work, and so it was necessary to give this Society a definite idea of the nature of the place that the Carnegie Institute of Technology has arranged to provide.

The commercial engineer will have to do with the solving of a great variety of problems, but there is one factor that is common to all, and that is the human factor, as dealt with through a study of psychology and its definite application in the scientific study of men, their work and their welfare.

The accompanying schedule shows that safety and welfare work has its allotted time for specific treatment, but many phases will be discussed in connection with other scheduled subjects, as psychology, economics, statistics, machinery analyses, production processes, works management, insurance, and commercial law and contracts.

It is impossible as yet to give even a synopsis of the specific course in safety and welfare work that will be given at Carnegie Tech. This will be developed during the next twelve months. There is an abundance of literature to draw upon, but the administering of specific instruction can only be developed in connection with classroom and laboratory work.

Before opening the general discussion, Professor Benjamin called on Mr. Albert W. Whitney[1] as the man largely responsible for the organization of the committees and the arrangements for the meeting.

A pamphlet had been distributed at the meeting, entitled The Teaching of Safety in Technical Schools and Universities, containing suggestions as to the incorporation of safety education in engineering curricula; subjects and speakers for safety lectures; safety exhibits, and bibliography of safety and accident prevention, etc. Mr. Whitney explained the purpose and contents of the pamphlet, saying that coincidentally with the entrance of this country into the war the arsenals and navy yards (through the assistance of the National Safety Council and the American Museum of Safety), and later the United States Shipping Board, were put upon a safety basis with well-developed safety organizations. This was not done primarily for humanitarian reasons; it was done for efficiency. It meant a saving in money, greater production, fewer wasted lives.

The safety problem is fundamentally psychological. What needs most to be done is to make men think in terms of safety. Just as the war is introducing the idea of thrift into the nation, so the idea of thrift in the saving of lives and limbs must be learned. Safety must take its place in the consciousness of people as part of the program of conservation, and conservation as part of the program of efficiency. In no way can this result be produced in industry more effectively than by education of the coming generation of engineers.

DISCUSSION

PROF. E. F. MILLER said that he had served for the State of Massachusetts in the draft of safety rules under the direction of the Board of Labor and Industry. The rules were general in nature and outlined the general methods of safeguarding —ladders, shafting, toe guards around pits, keyways, set screws, etc. There were representatives on the advisory committee of practically all of the large industries of Massachusetts, besides two insurance men. The manufacturers were inclined to feel that the insurance men were asking for so much protection that the output of the machines would be reduced, due to safeguarding. This led to an investigation in the woolen industry by the committee, and in one of the best-guarded mills of the country dangerous conditions were found, particularly in respect to belting. This disclosure brought about a more favorable attitude on the part of the manufacturer.

He said that the enforcement of these rules was left generally to the option of the Board of Labor and Industry, who would give a firm reasonable time to make the changes; but if not made, they had the power to shut down the plant. Professor Miller had served the state in an advisory capacity in cases of occupational diseases, etc., where it had been beyond the ordinary state inspector's ability to tell what to do to remedy the troubles. Some of the conditions which he found were so bad as to be almost unbelievable.

At the Massachusetts Institute of Technology instruction in safety subjects was given in connection with the course in factory construction. The protection of gears and pieces which were likely to catch a man's clothing were considered in the course in design. He felt that the reason why there had been opposition against the safety engineer was that many of the insurance inspectors who looked over risks had been so extreme in their recommendations that the manufacturers would not meet them halfway.

E. E. CLOCK emphasized the importance of safety devices for steam engines. To use an analogy, he said that a boiler has a safety valve and a damper regulator. The latter acts in the capacity of a governor, but it would not be safe to depend on this alone. The safety valve is essential. In the same way a steam engine is controlled by its governor, but people do not seem to realize that an automatic stop for ultimate safety is also essential.

PROF. JAMES A. MOYER spoke on a course of study prepared for the Department of University Extension of the Board of Education in Massachusetts by experts selected by the New England Council of Industrial Safety. This course, which is adapted to correspondence methods also, is to be revised during the summer months and printed in September of this year, when it will be available for use in the state.

[1] General Manager, National Workmen's Compensation Service Bureau, New York.

G. W. COOK explained that the course consisted of twelve lectures and was given to a class in Springfield, under the auspices of the New England Council of Industrial Safety, consisting of about forty-three members, drawn from the ranks of mechanics, millwrights and university graduates. There had been time for but eight of the lectures to be given, but the remaining four were to be given in the fall. The course was very successful.

CHARLES F. OAKES[1] believed that the trend of the whole discussion was toward standardization. The remarks on safety in mechanical construction were in line with a subject on which the Bureau of Standards had been working for the past four years, the standardization of safety practices. The Bureau's work in the past had been in a somewhat specialized field, electrical safety, but the success which had attended this work had moved them to broaden their scope to include industrial safety practices. This work had been initiated in the recent safety movement in Federal industrial establishments, and the movement, inaugurated in Federal arsenals and Navy Yards, had its inception at the instance of the Council of National Defense, with the assistance of the National Safety Council and the American Museum of Safety; the main idea of this was to check the number of accidents occurring in Federal plants by formulating a set of safety standards for equipment and construction. These had been submitted to the Bureau of Standards, who, working in conjunction with a committee of the Safety Engineers, had revised them, and it was expected that they would soon be adopted by the War and Navy Departments. There was little doubt, said Mr. Oakes, that a standardization of industrial safety along mechanical lines should be effected in much the same manner that the electrical industry was being safeguarded through the agency of the National Electrical Safety Code. This movement had been started in a number of states with little thought of nationwide standardization, however, by the State Industrial Commissions. In order to coördinate the work of the states, the Bureau of Standards had been suggested as the best medium of accomplishment. In the preparation of the electrical code about two thousand conferees had been consulted and the services of over thirty technical organizations had been called upon. It had had a wide distribution, and was now incorporated in thirty-two colleges in the United States. It was the intention of the Bureau of Standards, after the work had progressed to a degree sufficient to warrant it, to offer the services of its staff for lecture work among the universities as was now being done from time to time in the case of the National Electrical Safety Code.

MR. M. W. FRANKLIN[1] said that the time was not yet ripe for turning out specialists in safety engineering at the universities. A large percentage of our industries, aside from our highly-organized, large industries, had had no safety engineers. He believed, however, that the work which Mr. Whitney's committee had been carrying on in the development of specific courses in safety engineering was the most important thing yet attempted in the training of safety engineers, and would produce very concrete and immediate results. Mr. Whitney had had the forethought and the very sound judgment to choose people to assist in the work who had actual, concrete, definite experience. A course in safety engineering was necessarily so varied, so widely spread out and of such a broad nature that no one person was in a position to outline such a course. It had required the coöperation of very different persons with very different experiences to successfully formulate such a system.

Mr. De Blois, in closing, said that the Du Pont Powder Company, with between 60,000 and 75,000 employees, and whose numbers were constantly growing, would not consider the erection of a plant without first having an experienced safety engineer engaged on the work. Five years ago it was a difficult task to get a manager to realize that he needed a safety engineer. If he did get one, he didn't know what to do with him except to turn down his recommendations, but today the situation was entirely different. The company had found that it was easier to take a perfectly green engineer from the field, who had had no safety engineering whatsoever, and make a safety engineer out of him, than it was to take a man who had had five or six, or maybe ten, years' safety experience in general industries. They had secured candidates through advertising in the daily press, and from 300 applicants ten were selected for a six months' course of training. He believed that if there were available men from universities and technical schools, with the fundamentals of safety engineering and the ability to handle men, the problems which the industries were now having to face would be materially lessened.

WEDNESDAY EVENING SESSION

ADDRESSES were planned for this evening on The Procurement Program of the Government in order to present to the Society ways in which its members could best coöperate. Owing to conditions incident to the war, however, three of the speakers who had accepted were unable to attend, two of them sending their regrets on the day of the meeting. In spite of the sudden change in program, the session was entirely successful and of interest to the large audience in attendance.

PROCUREMENT OF SUPPLIES FOR THE NAVY

PAYMASTER C. E. PARSONS, U. S. N., who was one of the speakers originally invited, said that his principal reason for coming was to indicate to the members of the Society, and to the industries which they represent, the friendly feeling that the Navy entertains toward them. The big, paramount question now is that of getting material. While it has not been necessary to go outside of the Navy's own organization to provide for its increase in size, it has been necessary for both the Army and Navy to call to their aid the brains of the country in connection with material and the procurement of supplies.

Discussing some of the aspects of the procurement program, he said in part: There has been manifested the greatest interest on the part of the industries in this country toward supplying the Navy's needs. However, it is felt that even yet a greater interest can be taken, and that the Navy's business is sufficiently interesting to warrant all manufacturers attempting to get some of its contracts. Its dealings are conducted fairly and squarely, and one of its principal policies has been not only to do things right, but to do them in a way to indicate to every one that they are right.

[1] Bureau of Standards, Washington, D. C.

[1] Consulting Engineer, E. F. Fulton Co., Philadelphia, Pa.

There is no fairer basis for awarding contracts than that of competitive bidding. The Navy has held to that from the very beginning, except, of course, in those industries where the supply is not great enough to meet the demand and where it has been necessary to allocate supplies among the manufacturers, and necessary also for the Government to fix prices.

Standard specifications have been adopted, of which there are now about 1400, as a basis for equal opportunity for everyone. These are used by the railroads and by big corporations throughout the country, and even throughout the world. At the beginning of the war, owing to the changed conditions and the necessity for making prompt, immediate purchase of supplies, classified mailing lists were started. Before the war it was only necessary to advertise the Navy's requirements in order to enlist the interest of contractors and manufacturers; but now it is necessary to get into closer personal touch with them and bring to their immediate attention those things that they are in a position to supply. In order to bid on the business, therefore, it is essential that manufacturers should be on its mailing lists. It is desired that reliable firms should ask to have their names placed on these lists, and in turn it is attempted to make the lists of such a character that it is worth while for any manufacturer to have his name upon them. Brokers have been eliminated—the Navy has maintained a fight under great odds against the brokers, and has done everything possible to eliminate them in their dealings.

There have been reports among the industries relative to Government red tape, the very binding contracts, and the inspections which are so exacting, but in all cases it is believed that if any one will investigate the question fair-mindedly, he will find that these conditions are absolutely required, and particularly so for the protection of the legitimate and the honest dealer. The specifications are drawn up by the technical bureaus of the Navy Department, and these bureaus are entirely open-minded about changes in specifications. If any manufacturer thinks the material that is purchased or the specifications that we used are not proper and could be improved upon, he has only to advise the department of the fact and an investigation will be made, and in nearly every case the specifications are changed if a change is warranted. Under the present stress it may not always be possible to do this, but this is the policy of the department.

The contracts are big and the specifications voluminous, and carry provisions which often appear to the average individual when he looks them over as excessively in detail. As a matter of fact, nearly all the provisions have been brought about by efforts on the part of unfair contractors to take advantage of technicalities, which have made it necessary to set forth plainly, without a question of doubt, the provisions under which contracts are made.

As to the inspection of supplies, if an exacting inspection were not maintained and some one was permitted to furnish supplies below the standard, it would be unjust to the man who was bidding and expected to furnish just exactly what was called for, and fairly and squarely carry out his contract. Rigid inspection is essential for the protection of the honest dealer.

Very much has been said relative to Government red tape as the reason why industry has not interested itself more in the Government's requirements for supplies. As a matter of fact, red tape is simply organization and system, which must exist in an organization of the size of the Navy. But he said, "I will warrant that any chief of bureau in the Navy Department, or any official in the Navy Department, can be seen and consulted with less loss of time and with less difficulty than almost any president of a big corporation or firm. As a matter of fact, the doors are wide open, and we welcome people to come down and look us over.

"Particularly do we maintain that publicity is essential in connection with the handling of contracts. Bids are opened publicly, and people interested can be present when bids are opened and see the bids of any of their competitors. They can be assured that the awards are made fairly and squarely and that nothing is concealed."

The speaker referred to the growing tendency for Government regulation of matters connected with industry through the Fuel Administration, the War Industries Board and other agencies, and said that it was desirable for firms to have contracts either for the Army or Navy.

"We have found," he said, "even up to the present time, and it is going to be more and more so in the future, that we can be of great assistance to contractors if they have Navy contracts. We can procure fuel for them which otherwise they possibly could not get. We can arrange for transportation for the supplies which probably otherwise they could not get. We also attempt to pay promptly, and during the month of May we found that our average time for payment was only seven days after the supplies had been furnished and accepted."

In conclusion, the speaker stated that business had been placed on the east coast to such an extent, in the region north of the Potomac and east of the Alleghanies, that it would be almost impossible for more to be handled except where it was a continuation of that which contractors already had. The railroad facilities are inadequate to handle further business, and the Fuel Administration is unable to furnish the fuel for any further activities. All we can hope to do now, if we take their judgment as correct, is to maintain the present rate of production. It is necessary, therefore, to develop our great facilities in the West or in the South, in order that we may get supplies and carry on the war to a successful end.

INTERIM REMARKS

THE address by Paymaster Parsons ended the procurement part of the program, so far as Government supplies were concerned, but in respect to the procurement of speakers for the evening the work was only well begun. When word had been received that the other Government representatives could not attend, Dr. Irving G. Clark of Worcester, who had recently returned from service at the front, very generously accepted an invitation to address the meeting on his impressions and experiences abroad. Dr. Clark could not come until later in the evening and the President therefore called on some of the Society's able members to assist.

Professor Breckinridge enlivened the audience with some stories on the lighter side of university life. One of these related to a dinner which he attended, of the alumni and alumnae of a large western university, held in honor of a newly elected president of the university. Everyone was attired in evening dress except one man who sat at his right—but we will let the professor tell it:

"I didn't know who this fellow was—nice fellow, just as nice as any fellow with evening clothes on. Laughter. When the newly chosen president was called upon, to my surprise this fellow got up, and the first thing he said was: 'I perhaps ought to apologize to the ladies for appearing in these clothes, but it was this or nothing.' [Laughter.] Now, that was entirely accidental. They laughed over in this corner, and in this corner, then this corner. He tried to explain, but they

wouldn't let him explain. After he got all through he sat down. 'Well,' he said, 'I did put my foot in it, didn't I? The fact was, I expected to get home and get into those other clothes, but I lost my train.' I said to him, 'I have four jokes. I bet they won't laugh at any of them as much as they did at yours.'" [Laughter.]

At the meeting on Wednesday evening Professor Breckinridge told the other four jokes, but space requires that we refer instead to a more serious note which he sounded in concluding—a clear call to the young, prospective engineers of the country. He said: "We have heard what the Navy wants in material and about certain priority of shipment and priority of fuel which may be arranged for those who are making the things that the Navy needs. But I want to call attention to one thing that needs the attention of every industry. My experience is no different from that of many professors of engineering in all of our universities. It is that we need raw material for our universities and technical schools. Never was there a time when the teacher of engineering and the teacher of science was asked day after day, in telegram after telegram, 'Where can we get a man to do this and to do that?' to say nothing of the industries that are pleading with the technical schools to send them men. There are no men. There will be no men. There ought to be some priority scheme that will put raw material into the universities, otherwise we shall have troublesome times ahead."

Past-President Worcester R. Warner followed—his remarks are reported in full. He said: "When Professor Breckinridge mentioned universities, and the study of engineering subjects, it occurred to me how important it is to start from the right standpoint. This is illustrated by a happening at a certain university, which, being a western institution, was coeducational. It was in the class of mathematics and astronomy. The class had 'Time' for its subject that morning and the professor explained the reasons for the different kinds of time —mean solar time, sidereal time and the equation of time and all the problems incident to the study of time, in astronomy. It seemed that the entire subject was covered, and, in closing, he turned to one of his students in the class and said, 'Miss Brown, what time are you most familiar with?'—thinking that she would say, as you all would, 'mean solar time,' such as we keep in our clocks and watches; but a young man right behind Miss Brown whispered loudly, so that all could hear, 'Dinner time.' [Laughter.] Of course, all the students laughed. The professor laughed, too. He didn't correct them in the slightest degree, but he said, 'Ladies and gentlemen, that all depends on the standpoint from which you look at a subject. To Newton the fall of an apple meant the great law of universal gravitation, but it meant a very different thing to the pig that came along and picked it up. [Laughter and applause.]"

Chairman George I. Rockwood, of the local committee, then made a few announcements, when Dr. Clark arrived and gave a most interesting talk, a synopsis of which is printed below:

TALK BY DR. IRVING G. CLARK

Dr. CLARK spoke on conditions that he saw in France during his three years' work there with the Red Cross.

Life in France, where one experiences all the realities of a country at war, presents many changes which are hard for the pre-war traveler to reconcile. Women handle the train service —which is excellent—baggage transfer, the industries, farming, hospitals, etc. The large number of soldiers in Paris and great variety of uniforms make the streets most interesting. Few people understand the significance of the many different colors and insignia, for there are Belgian, English, Canadian, French and American, and all the subdivisions and colonials of these nations are represented. The life of the city is brilliant when it is quiet on the battle fronts, but much changed. The cafés that were open formerly up to two and three o'clock in the morning, now begin to close at 9.20 and are absolutely vacated by 9.30. The theatres still run until eleven, but after that Paris is a very quiet city.

There are fewer shops and prices are very high. Food is so expensive that an ordinary meal ranges from $1.20 to $6 in price.

Air raids are announced by sirens like the warning New York City recently planned. Every light is instantly darkened, indoors and out, except the blue light over the *alerte* signs which show cellar refuges to which all the people in the streets immediately run. These blue lights are less visible from above than the lights of usual color. Then starts the noise of the anti-aircraft guns putting up their barrage fire. The little flashes of light from the shrapnel appear, and the lights from French planes rising in defense. Soon the roar of the falling torpedoes is heard, and all interest centers in the speculation as to whether the next one will be nearer or farther away than the last.

Dr. Clark admitted that his feelings were always uncomfortable during an air raid, for he always had to be out at this time in order to reach Red Cross headquarters. Every one seems to feel easier when under cover, even though the cover is entirely inadequate.

The concussion from a torpedo which exploded about a mile away was sufficient to spin around three times a heavy plate-glass door and to knock people out of their chairs. The weight of the bomb generally carries it through two floors, where it explodes, completely demolishing those two floors. The building below that usually stands. All windows for blocks around are blown out, and the decorated paper pasted in to replace the glass presents an extraordinary sight.

The French are unable to joke about the air raids as they do about the "Big Bertha." The defense from aeroplanes is now much more effective than at first so that the enemy planes do not reach the city very often. Some new method of protection seems to have been used which apparently is a military secret, and very successful.

Air raids last from 40 minutes to 3½ hours, and at the close a welcome bugle announces that the danger is over.

The French make a little party of the periods spent in the cellar refuges, where they play cards, have music and enjoy meeting the new people who are obliged to seek shelter in that locality.

Dr. Clark spoke enthusiastically of the methodical way in which an immense amount of hospital work is turned off. The team work is splendid, no hurrying, but brisk, steady work. He found the morale of the men in the hospitals wonderful, and referred particularly to the work of two American physicians as an example of the loyalty and devotion which everywhere exists. They were operating in a French hospital, but under the direction of the American Red Cross. When the Germans were advancing the French were ordered to evacuate, but some of the patients were so badly wounded they could not be moved. The Americans, not being subject to French orders, decided to remain. Refugees and wounded came pouring in and the two American surgeons operated all day and all night and part of the next day until it was established that the French line was holding and the French were ordered back.

EMERGENCY TECHNICAL WAR TRAINING

The War a Matter of Ma ériel and Technically Trained Specialists. The Problem is That of "Re-educating an Entire Nation for a New Kind of War"

THE session devoted to Emergency Technical War Training, held on Thursday morning, June 6, in the lecture room of the Electrical Engineering Laboratories of Worcester Polytechnic Institute, was one of far-reaching importance. Inasmuch as the great need for technically trained men is constantly becoming more and more acute, it is vital that a comprehensive scheme for such training be speedily put into practice. The fact that considerable has already been done in this direction merely tends to emphasize how much has to be accomplished. For this reason Major James E. Cassidy, of the 301st Engineers, and an official observer at the French front in 1916, was invited to open the program by outlining the enormous scope of military activities dependent upon technically trained men. Professor Arthur L. Williston then spoke on the problem from the point of view of a director of vocational training. Lieutenant André Morize, detailed to the Department of Military Science at Harvard University, summed up the remarks made by the previous speakers in an inspiring address.

Following, Mrs. Frank B. Gilbreth, in the absence of her husband, Major Gilbreth, made a plea for an increased enrollment in technical schools and colleges. Motion pictures were then shown descriptive of the Browning machine gun, its operation and method of clearing, etc.

Mr. John R. Freeman, Past-President of the Society, took advantage of the presence of the motion-picture apparatus to show by this means a method he had employed in demolishing a smokestack, and the accuracy with which the stack was made to fall was demonstrated in a most interesting manner.

Vice-President Charles H. Benjamin presided, and a very attentive and enthusiastic group of members and guests profited by the remarks of the speakers. The following report is an abstract of the proceedings.

CONDITIONS AND REQUIREMENTS OF WARFARE

By MAJOR JAMES E. CASSIDY[1]

THE complexity of modern warfare has brought the engineer into a position that was never before occupied in the course of war. At the outbreak of the present struggle neither the Allied nor the Teutonic armies really realized what the war was coming to as regards the methods of fighting. Practically all previous methods of fighting have been relegated to the scrap heap to a certain extent. We saw for the first few weeks of the war a war of movement, where bodies of troops were engaged in maneuvering for positions and fighting in the open. Following the battle of the Marne, however, where the Germans were thrown back to the Aisne River, the war lapsed into a war of positions.

When the war of movement ceased and the war of positions began, then it became a matter of *matériel,* a term that the French coined to cover all the equipment and the appurtenances of war. The development of the war of position rapidly made the artillery—the mechanics of war—a very prominent feature, and also started the use of the airplane. Up to this time the airplane was considered nearly as dangerous to our own men as to the opposing forces. As an example of the trend of warfare, the grewsome works at Namur, Liège, Antwerp, Maubeuge, etc., were built to withstand a 6-in. artillery fire, which was considered the heaviest artillery that an army in the field could carry to any advantage. However, when the infantry failed to take Liège by storm they brought up Austrian 9- and 11-in. howitzers. There has been a great deal of newspaper comment on the work that the "Busy Bertha" and the 42-cm. howitzer were supposed to have done. As a matter of fact, it was not those guns that were used, but a size between those and the 6-in. guns, and the 9 and 11-in. howitzers that are believed to have destroyed the forts mentioned.

The War a Matter of Matériel

One of the best axioms or most emphatic axioms of this war is that men cannot combat matériel. You must destroy matériel with matériel before men can advance, before positions can be taken. The side that produces the greatest destruction of matériel is the side that is going to win the war.

To a certain extent up to the present time there has been more or less of a deadlock. The airplane situation is practically in that condition. For certain short periods one side has been able to overcome the matériel of the other, but on the whole there has been almost a stand-off. For this reason the war of movement has entirely ceased; the war of positions is on.

In former wars, if one combatant could maneuver around and capture the capital city of the other and get a good slice of his territory, peace was declared. In this war territory means practically nothing. The function of the army of today that wins consists of three things: the destruction of men, matériel and morale. The destruction of matériel is the prime factor in the destruction of men, and the destruction of men means the destruction of morale. We have seen it in various fightings; for instance, where the Germans hurled their masses on the French positions and were simply slaughtered. The same thing occurred in the first and second battles of Ypres in 1914. The same thing has been occurring in France and Belgium in the last few weeks of fighting. The price the Germans have paid for a few square miles of territory has been entirely out of proportion to the advantage gained. Their reserves and the disposition of their forces are necessarily limited, and when their reserves are wasted they have nothing further to draw upon. Their only hope, as a wild gambler's chance, was to do something big, but the British, French, Portuguese, Americans, and other men that have taken part in this fight have tended to destroy that one gambler's chance, and as time progresses it will be completely destroyed. The slaughter of men—the Germans fighting *en masse*—the slaughter of men who are forced to move forward under the murderous fire of machine guns and rapid-fire artillery, undoubtedly has its effect on the morale of the soldiers and is bound to tell in time.

The part that we can play in this war and will play is a very great one. By superhuman efforts on each side there is now a certain amount of deadlock in the situation. In the air the Allies have maintained a small supremacy. They have the speed and the maneuvering ability and, on the average,

[1] 301st Engineers, Camp Devens, Ayer, Mass.

they have the better class of fighters—they are airplane fighters. But on the whole it has been to a certain extent a stand-off. We are coming in with fresh forces and unlimited reserves, and while we were laggards for three or four years we have made great strides the last fourteen months.

In a lecture yesterday morning, Colonel Paul Azan, chief French military attaché in this country, mentioned the need for a lighter mobile field gun than is at present in use. We have the 75, which is practically the 3-in. gun; then the next step down the line is the 37-mm. gun, which is a very effective gun but only fires a 1-lb. shell. If the mechanical engineers in this country can produce a gun somewhere between those two, say, one of 2¾-in. caliber and much lighter in weight, they will be doing an enormous service toward ending the war. Colonel Azan has gone all over this country in connection with military work and says that he never fails to speak of this when he is addressing any body of men, whether soldiers or whether civilian societies, in the hope that some one will take the idea and work on it.

The Part Played by Engineers in the War

The question, then, outside of the production of matériel for the armies, comes down to the part the engineer is playing in this war. Well, it is no small one. The corps of engineers in this country at the outbreak of the war consisted of 200 officers and 2100 enlisted men. Our organization today consists of 252 regiments and about 108,000 men and 7000 officers. For fourteen months that is not bad, and our proportion is increasing all along. In the time at my disposal I can merely mention the different activities in our Army that have been turned over to the engineers.

For instance, we have the work of mining and sapping; the various classes of bridge work—pontoon and other classes used in the field; and the mining of deep gallery shelters, a very important feature on the fighting fronts of today in the war of positions. For several miles from the front lines all the soldiers live in deep gallery shelters. With the modern high-angle artillery fire one is not perfectly safe in a deep gallery shelter unless he has from 25 to 30 ft. of roof over his head. Major Rousseau of the French engineers, in commenting on that point, stated that often a mistake was made in constructing a machine-gun shelter with only 4 or 5 ft. of earth overhead, and said that a piece of sheet iron would serve equally as well, because neither would turn even the smallest shells.

The work of demolition and the defense against the poisonous gas used by the Germans has been turned over to our engineer service. Then we have the searchlight service and camouflage paint service. We have not progressed so very far in tanks yet, but have a tank corps organized and tanks under construction or under contract. We have a railway transportation regiment which has been turned into a corps, and the gas and flame offensive service. Then we have the map section of the engineers and quarry regiments to quarry and crush stone for road work. One of the primary things of the war today is getting up supplies; and the building of railroads and ordinary highways has involved figures that are staggering to the ordinary individual. Then there are tunnel companies for various kinds of tunnel work, mostly back in the zone of the interior.

Cantonment Construction Abroad

With reference to cantonment construction abroad, I would say that most of our troops are billeted in France. For instance, a certain village will have every house and every barn marked with the number of men it will accommodate and the town major has a complete list of every house, knows exactly where he can have his headquarters and knows how many a certain building will shelter. I believe the usual basis of figuring that billeting is about seven soldiers to one civilian inhabitant. In our training areas back behind the lines, however, we build cantonments differently from what we do in this country. Here we have simply let contracts for the erection of buildings; for use abroad we have furnished portable, or rather, sectional, houses. The original design was for houses 20 ft. wide and 237 ft. long. The doors were put on a panel, the windows were put in and the roof was in sections. The only thing not built up here was the floors. The work was parceled out to 15 mills and enough of these buildings were completed in 60 days to house 500,000 troops. So far as I know, that system has been continued.

The large army of today not only needs plenty of food supplies and ammunition but it needs water as well. So we find the Germans poisoning wells and dropping in bodies of animals and men or anything to destroy the value of the water for immediate use, making it necessary for the engineers to plan for a water supply to follow the armies, run pipe lines up, dig wells, and take steps for purifying water. Then we have our general construction units which do all sorts of general construction work back in the zone of the interior. We have the general repair shops and supplies. We have railway-construction regiments. There is one particular regiment—the 23d Engineers—that is organized for highway work and will ultimately have under its direction an immense force of German prisoners.

I happened to have one of the battalions of this regiment under my charge for tactical instruction at Washington barracks last December, and an amusing incident occurred in connection with the Second Liberty Loan. One of the enlisted men went around to men in his regiment asking for subscriptions to the Liberty Loan, and he came to one man, a private, and asked him if he didn't want to subscribe. He said he believed he did. "How much shall I put you down for?" said the solicitor. "I will take $100,000 worth," said the private. The soldier thought that was a great joke and rather laughed, but the private told him, "If you don't think that that is all right you can wire ——," naming a certain bank in Pittsburgh. The soldier reported the conversation to his superior officer, and the officer said, "All right, just wire this bank for curiosity." The answer came back, saying that if this man wanted to take $5,000,000 worth of Liberty Bonds he was perfectly good for them. [Laughter.] That is a little illustration of the cosmopolitan composition of this regiment. In it there are men serving as privates who have had 10 or 15 years' engineering experience, consulting engineers, some of them. You will find there almost every class.

Then our railway engineering corps is very elaborate. We have the standard-gage construction and operation men. We have the 60-cm. units and the 40-cm. The 40-cm. are light railways that are built up in the trench lines, leading up to the front lines, and the 60-cm. are back of them. The 40-cm. lines are entirely for small cars moved by hand. The 60-cm. cars are partly horse-drawn and partly drawn by small locomotives, either gas or steam. We have sent over a great number of cars and engines. Our equipment in this country is very much heavier than the standard equipment in Europe, and where we can use our engines and cars without going

through tunnels, we send our equipment. Then to keep up this railway work we have our railway shop regiments, of which there are quite a number. Then of course we have field fortification and fortification in general, and recently aerial photography has been turned over to the engineers. It seems that when they run into anything that nobody else wants particularly they immediately put it on the engineers!

Taking of Messines Ridge by Engineers

Any one of these different items is a story within itself. In regard to some of them I probably could spend an hour talking on one particular feature, but I want to mention a few things that have come under the scope of the engineers, for instance, in taking Messines Ridge. There has not been a great deal published on the actual details of taking Messines Ridge, but for 16 months previous to the taking of this ridge by the British and Canadians they were very busy tunneling this hill. It was a point the French and British had fought over in the early days of the war; in fact it had been retaken once or twice for short periods as the tide of battle swung back and forth. It was a ridge that overlooked the British lines and was rather a thorn in the side. For 14 months before this attack was made the British were busily engaged tunneling this hill, running mine galleries. There were 24 of these mine galleries and their average length was over two miles. These galleries were about 4 ft. by 6 ft. and as the earth had to be carried out and disposed of so that the Germans would not know any more about what was being done than possible, it was quite a tedious task. The Germans knew that the British were mining this hill, although they could not tell where. Owing to the geological conditions of this particular terrain there was a stratum of clay above the British tunnels acting as a muffler, and while the Germans could tell by the sounds that there was mining going on, they were not successful in doing any countermining. The idea is that when any one is running a mine gallery up to your trenches, you should countermine and blow him out with what is known as a counterflame, that is, a small shaft that runs into his mine. The British played a little joke on the Germans. The Germans were holding Messines Ridge as lightly as possible, knowing that tunneling was going on, but not being able to locate the mine galleries. These mine galleries were eventually finished and branched out in different directions under the German lines, and a million pounds of aminol was placed in them. This aminol, which is very much of the same nature as our TNT, was put into rubber bags and these bags were placed about four months before they were detonated. The British played their little trick by placing their mines and then waiting for an opportune time, because the Germans, after the British stopped digging, got over their scare. It is rather trying on the nerves to know that some one is mining under you and you are unable to find him—it shakes the morale of the best troops. So there was a period of about four months that they waited after the mines were laid and the Germans had gotten over their nervousness and Messines Ridge was held very strongly. Then one morning, at exactly four o'clock—and I might say in this connection that very great care is always taken in any sort of movement to see that all watches are absolutely synchronous; every watch must be exactly with the others, there must not be thirty seconds' difference—the million pounds of aminol was exploded and every gun on the British side started firing. The whole top of Messines Ridge was practically blown off, and the country seemed to rock for about ten minutes. The British troops moved forward without very many casualties. The Germans were simply stunned by the artillery fire and the explosion of those mines. Following the explosion of the mines a novelty was introduced in the way of machine-gun barrage, the Royal Engineers having placed machine guns about 1800 yd. behind the British positions.

The Italians performed a similar feat in the Col di Luna in the Dolomite Alps. Those peaks are very jagged and the Austrians held a post on a small peak that the Italians could not get at. On January 16, 1916, they had prepared to go after this peak and they moved in compressed-air and other necessary machinery under the shelter of a ledge, some 4000 ft. below the Austrians who were up on the top of this peak. They started their tunnel, ran it up at an angle of 45 deg. for about 4000 ft. to get under the Austrian position and spread out in a sort of fan shape and placed 95 tons of aminol under this position. On July 16 they exploded the charge and there was nothing left of the Austrian position, not even the top of the peak. The whole top of the mountain was removed.

These are but isolated incidents out of thousands. I am sorry I have not the time to describe the engineer's progress from the time he arrives at a port in France and show what he does up through the lines and up through the entire country. This it was my original idea to do, but I have just mentioned these few little instances.

SPECIALIZED TRAINING OF TECHNICIANS

By ARTHUR L. WILLISTON

I APPEAR here on this program this morning in a dual capacity: First, as the chairman of a committee of our own Society which was appointed shortly after the January meeting to see if through the agencies of the Society work might be stimulated to increase the number of men in the United States who had some kind of specialized ability of one sort or another that might be useful in connection with this gigantic task in dealing with the matériel which Major Cassidy has just told you about; and, secondly, I am here as representative of the Committee on Education and Special Training created within the War Department by special order of the President through Secretary Baker on February 10, which created within the War Department this special organization charged with very wide responsibility and duties in connection with the development of specialized technical skill in the shortest possible length of time—intensive war training of technical or artisan character.

The War's Demand on the Engineer

Major Cassidy has pointed out with emphasis and clearness the remarkable way in which this war differs from all other wars and the supreme way in which matériel of extraordinarily varied and complicated character enters into it from start to finish—absolutely through every part of the work. We on this side of the water are more or less thrilled by the wonderful exploits of airplane, of submarine, of wireless and one and another of the very recent and startling advances in applied science. We often fail to realize, I think, the extent to which gigantic engineering problems calling for exactly the same kind of intelligence and accurate planning and skilful application and unusual skill or technical abilities enter into the handling of all the mass of matériel. The question is not one of dealing necessarily with these unusual

factors so much as it is the kinds of big engineering propositions that this country used to think of in connection with our great industries. It is a problem of transferring, transplanting a certain number of thousands of tons of iron and thousands of tons of steel or gas or inflammable material or some other necessary factor in the situation from one place to another with precision, on time, with the least possible effort and with the maximum effectiveness—the same kind of problem that the United States Steel Company has to meet in Pittsburgh. And it calls in an extraordinary degree not only for the engineer who plans at the top but for the whole personnel, all the way down the line from commanding general to rear-rank private, for the same kind of organization, the same kind of ability to do the particular job at the right time in the right way that great industries in America or great engineering enterprises of one sort and another call for.

Urgent Need of Additional Shipping

The difficulty in transporting troops on account of lack of ships from this side of the Atlantic to France increases tremendously the need for giving every possible particle of training that can be given on this side of the water so that the men may be prepared to be effective at the earliest hour after they arrive on French soil. We fail to realize some of these things, I think, to understand that the preparations for increasing the Hog Island plant last winter were going on at the rate of approximately four times the maximum rate of construction of the Panama Canal at any time, and that similar increases in shipbuilding plants throughout the country totaled possibly thirty times the Panama Canal so far as one can contrast one method of construction with another.

The Special Obligation of the Society

I am saying this simply because I wish to get The American Society of Mechanical Engineers and its entire membership to appreciate that we need not engineers alone but we need a supply of technicians, of new kinds of artisans all along the line. And there is not in existence the supply. President Wilson might have said when he described this war, "It was a problem of reëducating an entire nation for a new kind of war." No body of men in America can understand the nature of the problem so well as the members of The American Society of Mechanical Engineers, I think. And on them, because of that ability to appreciate, is a special obligation to come forward and exert in every possible way a public sentiment which will help this work forward as nothing else can.

THE NEED FOR SPECIALISTS IN THE PRESENT WAR

By LIEUTENANT ANDRÉ MORIZE[1]

As Major Cassidy a few moments ago pointed out, the warfare of today presents a new character, being a war of fortified positions. This means that we have to abandon completely the words and the idea of field warfare or open warfare. These words have not meant anything since the battle of the Marne, since September 1914, when the two armies began to dig themselves in and to organize the long lines of fortified positions which run from the North Sea down to the Swiss border. It does not mean that the fighting will be confined to the trenches, but it means that after all the battles the armies will find themselves again in fortified positions, organized lines of trenches, defensive organizations, and that the fighting on the open ground will be limited always to the pursuit of the hostile forces from one fortified position to the next fortified position. And when it shall happen that the army which is attacking does not find the hostile army fixed on an organized position, after a few days, the war will be over in less than a week.

The Need for Technical Training

What does that mean now? After the first blow the Germans were able to get through the first line, through the second line, possibly through the third line of Allied positions, but now they find again the French and British and American troops established on fortified positions hastily dug during the first day but improved day after day, hour after hour. And now they have to start again in the same manner, march to the new position—the attack of a fortified position, and it is absolutely wrong to oppose the two terms of trench warfare and open warfare. It is very important for the right direction of training to realize the new characteristics of the war of positions. And the point I wish now to emphasize is that, given the new character of the war of today, the men—more than the men, the officers—are perfectly useless if they have not had a complete technical training. Why? First, because the war now is a war of specialists. And all the men engaged in the present war must be specialists because the old conditions of the fighting are all gone, and to reach the enemy sheltered in fortified positions, using heavy artillery and new weapons such as gases and flames—as well for the attack as for the defense, it is necessary to have men with special training and technical training.

The rifle and the bayonet, the weapons of the old-time fighter, are still useful, and it is wrong to believe that the French and the British are going to abandon them more or less—not at all. Our men are trained in the use of the rifle and the bayonet, but the rifle is useful only in special cases when we can fight on open ground between two positions, and the rifle and the bayonet are absolutely powerless against men sheltered in deep trenches and in dugouts. So our men, the plain infantrymen, must be trained in the use of all the new weapons—grenades, bombs, smoke bombs, incendiary bombs—and in the use of the trench mortars. Besides the infantrymen we have the men trained for gas warfare, for liquid-flame warfare, and finally we have all the new kinds of weapons which under the name of "tanks" are nothing but assault artillery, artillery used in close coöperation with infantry, advancing with the attacking lines and sometimes preceding them.

The War One of Specialists

I cannot give more details about these different lines, but it will be seen that the war is now fought entirely by specialists and that these specialists must get a technical training. It is impossible to improvise in a few days a man for a gas attack. It is impossible to improvise in a few days the man to use bombs and hand grenades in a satisfactory way. We need men and officers with technical training.

A second reason which makes technical training more and more necessary is the fact that the present war is a war of close coöperation between the different arms of the service. If we think of all former wars it is easy to realize that

[1] French Military Mission, Northern District; detailed to Department of Military Science and Tactics, Harvard University.

infantry had to play the most important part—and sometimes alone—helped by artillery, but it was possible to think of infantry fighting, pure infantry fighting. Aviation was unknown. Engineers had to play but a small part. The supply service, the railroad service, were useful, but not as necessary as they are now. If we now think of the conditions of a large battle—one in which all the resources of the two armies are engaged—it is easy to see that the battle is the common task of all the branches of the service, as any one of the different branches, infantry, artillery, aviation, working alone is helpless. Even for an operation like the capture of a few miles of hostile positions all the arms of the service must work at the same time, and now all the branches of the service need men with technical and complete training.

Training in Use of New Weapons Necessary

In the infantry all the men must be more or less specialized in one of the new weapons now used—grenades, trench mortars, machine rifles, machine guns, etc. In the artillery the conditions of the work are now quite different from what they once were. The old idea of the artilleryman was a man with a technical knowledge of the gun and its different parts, and familiar with its tactical use. But now artillery work means, first, the technical knowledge of the science of adjusting fire with the long-range guns and with the difficult task of adjusting fire at small targets, sometimes very well camouflaged; second, technical knowledge of the science of locating, of spotting the hostile battery. That is a complete organization now. We have two such large organizations that started in the French army under the names of *sections de repérage par le son* and *sections de repérage par les lueurs*. These mean spotting the hostile batteries, first, by observing the sound, and, second, spotting them by the flash of the battle. They are complete scientific organizations with special officers, and they play a very important part in all the operations now. When it is realized that it is impossible to launch an offensive today without first silencing and neutralizing all the hostile batteries, it is easy to realize the importance of the rôle played by the men who have to locate the hostile batteries by their technical knowledge.

Third, technical knowledge of topography. The topographic work is a part of the artillery work because, given the long range of the guns, the use of the ground to conceal the batteries behind the hills and the contour of the ground, most of the adjusting work is done entirely with the map; and so the necessity of making, drawing and reading maps—technical knowledge for artillery work.

Fourth, the batteries are exposed to hostile fire, so the first condition to be able to destroy the hostile position is to have a good protection for our own batteries, and the technical knowledge necessary to build the batteries and emplacements—to know exactly the conditions of resistance of materials, to know how to use the ground, and the different kinds of supplies to protect the batteries as much as possible —technical knowledge necessary for such a job.

Question of Artillery Transportation Most Important

Very probably the most important point now is the question of transportation of artillery. If the Germans, as Major Cassidy pointed out, have been able to advance so fast in the last few weeks it is because they have been able to find new methods of transportation for artillery. All the preceding drives have been more or less limited to the range of the long guns—six, seven or eight miles. The depth of the German advance is now much greater and wider only because they have been able, thanks to their technical ability, to find more efficient means of transportation for artillery. The question of the transportation of artillery material, and especially of heavy guns and heavy ammunition, is one of the most important problems of today. So you see that relating to artillery alone at least five points require technical knowledge.

I will not speak about aviation; aviation is nothing but a technical branch of the service. But just one word about the connection between all the different branches of the service. Each of them needs a technical training. But to connect them, to have them work together, to realize what we call the *liaison* between the different arms of the service, we need more than ever men with technical knowledge. Liaison between the different arms, between infantry, artillery and aviation—the liaison between the different units and the high command—means organization of telegraphs, of telephones, of wireless, of ground telephone, ground telegraph and visual signaling, searchlights, etc. For all these different means of liaison we need men with technical ability and technical training.

And finally, Major Cassidy emphasized the point that the present war is a war of matériel and of supply. It means the question of production in this country, the question of transportation of troops, men, food, supplies, equipment and everything; and the question of distribution of the supply of the ammunition at the front. It means, as he said, the organization of an extensive network of railroads, regular and field, depots, stations, etc. So you see a war of positions, a war of specialists, a war of coöperation between the different arms of the service, a war of matériel and of supply. From all these different points of view the war is now of such kind that all the men engaged must have a complete technical education and training. And not only the men engaged in the special technical lines, but even the most modest infantry officer; a second lieutenant now, leading the platoon, must be able to know about liaison of the telegraph, telephone, about the digging of a dugout, about the organization of a drainage, etc. Technical education is accordingly of first importance and it is the duty of all to help those directly engaged in military training to make the country realize these new characteristics of the war. The war will not be won by men with rifles and bayonets. It will be won by the effort the whole country will make in order to meet the requirements of the new kind of warfare we have—the war of matériel, the war of supply, and the war of technical knowledge.

John R. Freeman, during the session, had projected on the screen a short film showing a method he had used in demolishing an abandoned factory chimney. The chimney was a radial brick stack 160 ft. in height. The work was accomplished in the short space of four hours' time. The method shown consisted in digging a hole in one side of the chimney, in which a cobhouse blocking of hard pine was then loosely built. The weight at first was all taken at the point where digging was started, and the question of having the chimney fall in the direction desired was one of tearing bricks out from each side of the starting point an equal distance at a time. The wood blocking was then saturated with oil and set on fire, and when sufficiently consumed, the chimney fell on the side from which the bricks had been removed.

In falling, the chimney came within two feet of centering on the spot selected in advance, demonstrating the precision with which the method can be worked.

SECOND GENERAL SESSION

THE second General Session was held on Thursday morning, June 6, in the Mechanical Engineering Building of the Worcester Polytechnic Institute, and, considering that the session was held simultaneously with two other attractive sessions, it was well attended and a lively interest was manifested in the five papers presented for discussion. President Main presided for the first half of the session, when he turned the meeting over to Vice-President Greene, who concluded it.

The six papers, in the order of presentation, were: Efficiency of Gear Drives, by C. M. Allen and F. W. Roys; A Self-Adjusting Spring Thrust Bearing, by H. G. Reist; Air Propulsion, by Morgan Brooks; Electric Heating in Molds, by Harold E. White; The Elastic Indentation of Steel Balls Under Pressure, by C. A. Briggs, W. C. Chapin and H. G. Heil; and Stresses in Machines When Starting and Stopping, by F. Hymans (by title only).

Although the subjects of the papers were so varied, participation in the oral discussion was general, and the proceedings of the session, with the large number of written discussions contributed, were somewhat voluminous.

Professor Allen presented the first paper, which described an apparatus, set up in the laboratory of the Institute and on view before the session, for measuring the efficiency of gear drives by measuring directly the power loss through them. An electric motor is so hung in a cradle that both its armature and field are free to turn. The armature shaft is connected directly to the pinion gear shaft and the driven shaft directly to an Alden absorption dynamometer. The reaction of the motor field is balanced by the action of the absorption dynamometer through a simple lever. The arms of the lever are accurately proportioned to the ratio of the gears.

The paper illustrated methods of calculation and gave data of efficiency tests of both worm- and bevel-gear drives.

President Main, H. G. Reist, Prof. W. H. Kenerson, Prof. A. A. Adler, R. G. Nye and Prof. W. W. Bird discussed the paper. The trend of the discussion was that the results given should be somewhat discounted, to which Professor Allen replied that the paper had been written simply for the purpose of presenting a method by which any one could test gears and get results without much trouble; he thought that some other agency than the Institute should be prevailed upon to carry out reliable experiments, having the method provided.

Mr. Reist's paper, presented by the author, illustrated spring-thrust bearings for vertical water-wheel driven generators, to carry a load of 300,000 lb. at 100 r.p.m., cited allowable unit pressures, and described the construction of the bearings. In these bearings one of the surfaces is made to yield at any point by using a comparatively thin plate supported by a large number of springs. The pressure usually allowed is 300 to 400 lb. per sq. in., the design permitting a very thin oil film without metallic contact.

Professor Adler opened up a discussion by calling attention to some of the steps in the history of bearing theory, which he promised to write up in mathematical shape later. He then asked the author some questions regarding film lubrication and also alignment.

C. A. Briggs said he had seen the bearing under test at Schenectady and it had impressed him favorably.

Professor Adler continued with questions, mostly for information, and Mr. Reist answered them in turn.

Professor Brooks then presented his paper, describing experiments to show that the screw theory for propellers should be replaced by the theory of reflection or batting action. By means of two electric fans and an anemometer he demonstrated how air can be driven by a propeller at a velocity nearly twice as great as the product of the pitch and the revolutions. He said he knew the idea would be received with skepticism, but he would welcome suggestions regarding its explanation and proof.

As was anticipated, both the written and oral discussions were lively, some discussers receiving the paper with enthusiasm and some contradicting the author's conclusions entirely. The terms "sustentation," "superspeed," "vortex," "stream line," etc., were frequently cited; and, in fact, before the discussion was over all the nine theories of propeller action had been brought up.

Those contributing to the discussion were N. W. Akimoff, H. G. Reist, W. C. Durfee, C. W. Howell, G. D. Bothezat, H. F. Hagen and C. A. Briggs, and justice can only be done to their remarks by printing them in full later.

Mr. Briggs then read his paper on indentation, which described experiments carried out at the Bureau of Standards showing that the indentation of balls pressing against flat surfaces was not directly proportional to the pressure but to the two-thirds power of the pressure. These experiments were developed in connection with the adjustment and standardization of precision apparatus incidental to the manufacture of munitions gages.

The discussion of this paper was light, questioning the author on the materials, shapes of surfaces and pressures which he used and those which his results could be extended to apply to.

Mr. Harold E. White presented the next paper, which he said was a practical paper, illustrating a mechanical engineer's method of utilizing induced electric currents and hysteresis losses in solid iron to heat molds, the method being one which electrical engineers instinctively turn away from, as they usually laminate every magnetic circuit they possibly can.

Though the interest in the topic was not large, the paper was well received, and the author was asked a number of questions by Mr. W. H. Marshall which excited the interest of those present.

Mr. Marshall's main requests were in regard to the practicability of melting glass in molds heated as the author described. Mr. White thought this, on the whole, impracticable.

The last paper scheduled was a mathematical paper by Mr. F. Hymans, giving a new method for the correct evaluation of the forces acting on machine parts during start or stop. The method was illustrated by application to a vertical geared hydraulic hoisting machine.

There were no oral discussions of this paper, but written discussions were sent in by N. W. Akimoff and Prof. S. E. Slocum. These will be printed in full later.

Mr. Akimoff eulogized the paper, saying that no true engineer could help feeling a better man for having studied it. It was not difficult and was very clearly written. He entered a plea for more members of the Society to interest themselves in the finer points of this character.

Professor Slocum was of the opinion that the author's application would apparently afford a considerable refinement in the calculation of stresses of machine parts. He thought the author's use of the unfamiliar normal coördinates, while it served to show the generality of the method, complicated the solution somewhat, but he did not offer this as a criticism.

There being no further discussion, the meeting adjourned.

EMPLOYEES SERVICE SESSION

Thursday Afternoon Meeting at the Norton Company's Plant for the Discussion of Industrial Housing and Other Requirements for the Welfare of Employees

A PROFESSIONAL session of exceeding interest, at which employment methods, labor turnover, and welfare measures for promoting and conserving the health of employees were among the subjects considered, was held in the administration building of the Norton Companies' plants at 2.15 p.m., Thursday, June 6, Past-President James Hartness acting as chairman. Four papers were presented at this session, the first two dealing with the important subject of housing conditions.

THE WORKMAN'S HOME AND ITS INFLUENCE UPON PRODUCTION IN THE FACTORY AND LABOR TURNOVER, Leslie H. Allen.

INDIAN HILL: AN INDUSTRIAL VILLAGE CREATED BY THE NORTON COMPANY, Clifford S. Anderson.

EMPLOYMENT METHODS AS FOLLOWED BY THE NORTON COMPANIES, E. H. Fish.

VESTIBULE SCHOOLS, J. C. Spence.

Mr. Allen's paper was published in the June issue of THE JOURNAL; the texts of the others immediately follow in slightly condensed form.

INDIAN HILL: A MODEL INDUSTRIAL VILLAGE

BY CLIFFORD S. ANDERSON,[1] WORCESTER, MASS.

UP to the present, the Norton Company has not been called upon to meet and solve the industrial housing problem as it is generally understood. Many concerns which have been located in the smaller towns, in order to provide homes for their workmen have had to practically create a local village. Other industrial plants situated in large cities have felt it imperative to bring about an improvement of home conditions for employees previously living in slums. We have fortunately been situated on the outskirts of an industrial city to which laborers are constantly attracted. It is a city which up to the present time has no slums. As a matter of fact, our lower-paid employees are able to secure living accommodations that are safe and light and well ventilated, and as clean as the occupants are inclined to maintain them, at a price commensurate with their income, more readily than any group of our workmen. Accordingly, we have not set out to approach the problem from the bottom but rather from the top. Our aim has been to make it easy for our foremen and more progressive workmen to obtain for themselves homes of taste and convenience, likely to make the employee happy and contented with his personal work, to improve his taste, stimulate his ambition, lead him to assume without terror some of the responsibilities which fall upon men of all stations in life, and to furnish for the other employees tangible evidence of the thoroughly satisfactory and worth-while things of life which may be secured by diligence and industry, and so stimulate in them a desire to make themselves more useful, to improve their conditions of living, and to so win for themselves and for their families a bigger share of the truly good things of life.

The Norton Company has embarked on this work, not solely with the idea of indulging in philanthropy, but from the point of view of enlightened self-interest, considering the return in loyalty and intelligent labor, and the probably increasing values which are likely to result from the development of the Indian Hill community. We have given our workmen nothing but an opportunity. The land cost them all that it cost us. The houses erected thereon cost them all that they cost us. We have simply furnished them the opportunity to buy a home not only on easy payments but at cost, an opportunity which is not elsewhere extended to them. The Indian Hill community is a corporation, the stock of which is held by the Norton Company, and was brought into being merely to handle more easily the work of creating an industrial village. The policy of its board of directors, which is identical with the directorate of the Norton Company, is to administer its affairs without profit and without loss; all of its activities are purely business, its purpose, to insure to our workmen the opportunity of an attractive home at cost, without exacting a penny for the profit of others, and to insure to the stockholders, in other words, the Norton Company, the business-like execution of this mission without a penny of loss.

When the village was originally opened in 1915, there were, of course, many who rushed in to avail themselves of the new opportunity, but there are residents on the hill who have been invited to come there by the company, families whom we felt would be leaders in the community, and contribute to the success of the village life. We have not hesitated to suggest to certain employees that they undertake a considerable financial responsibility in securing a home in this way, for we have found from experience that the appreciation of these opportunities up to a certain point is in direct proportion to the sacrifices that are required in order to enjoy them. Yet I do not think that in any case periodical payments are being made upon a house in excess of 25 per cent of the income of the residents.

In starting out upon our program we were fortunate in having right at the very doors of our works an ideal site—a beautiful hillside overlooking the waters of Indian Lake, with an opportunity for gentle grades and slopes for the roads which have been availed of to the greatest extent by the architect, Mr. Grosvenor Atterbury, of New York, whose services we sought because of his similar work in connection with the Russell Sage Foundation and their housing problem. The idea was to establish here homes which should be substantial, resistant to fire, would not require a large cost of maintenance and which would combine taste with efficient relation to the need of the class of workmen who were likely to reside therein.

In the very first instance the company decided that the relation of employer and employee was sufficiently intricate so that we did not want to assume also that rather difficult relation of landlord and tenant. Consequently none of our houses are rented; all are sold. We were fortunate in securing the land at a low price and offered it to our workmen at the actual cost per foot, including the improvements, and built the houses for them through our own hired contractor. There are five or six different styles of houses so that that unwholesome uniformity that used to dominate an industrial village is presently lacking.

The question came at once, how should we finance our scheme? We decided that we would sell direct, giving a full

[1] The Norton Company.

title to the buyer, taking back a mortgage. We require of the purchaser an initial payment of 10 per cent of the cost of the house. He gives us in addition a time note for 12 years and a demand note. These are secured by a mortgage to the company. We require of him also that he take out a certain number of shares in a coöperative bank, and the local banks, at the rate of interest which has been adopted, have brought about the following state of affairs: that a payment of a dollar a month results in a return of $200 in 12 years. Consequently at the end of 12 years he has, without making any direct payment to us, saved a sum sufficient to pay off the time note, and that sum, with the initial payment, brings him to a point where he may then look to a bank in the city and have a first-class bank mortgage and own his house under the same conditions that prevail among those in more fortunate circumstances. In many instances the owners of these houses are occupying them and virtually securing the ownership thereof at monthly payments which do not exceed the amount which they were previously paying as rent for tenements in which they never had any lasting interest.

We built first in 1915 twenty-seven of these houses and thirty more in 1916. The prices in 1915 ranged from $2850 to $4000; in 1916, from $3600 to $5200.

The cost of these houses was 16 cents per cu. ft. in 1915, and 19 cents in 1916. Mr. Atterbury informs us, however, that the same house we have been constructing was constructed in 1916 in Tennessee for 10 cents per cu. ft.

It is too soon for us to tell what we find registered in increased loyalty and increased work in the factory due to this one project alone. We feel sure that the effect will be to attach the workmen to our company. On the other hand, we have been careful not to chain them to the soil. The possessor of an Indian Hill house may leave our employ and still retain his home. The purchasers of our houses are also free to sell, this provision only being made, that having a bona fide offer in writing from another they shall be prepared to offer the house to us at the same price, so that if we do not approve of the new village occupant we may take the house over and seek new residents for ourselves.

The increasing village life has been interesting. The owners of these houses have formed their own improvement society and have recently made appropriations for the beautification of their village. We feel sure that the work has been started successfully and we look forward to greater influence in the future.

EMPLOYMENT METHODS AS FOLLOWED BY THE NORTON COMPANIES

By E. H. FISH,[1] WORCESTER, MASS.

WITH the growth of any business there comes inevitably a time when the management feels its separation from the men who are actually engaged in production. Such a time is apt to come soon after the number employed pass the thousand mark; then it becomes necessary to find some organized means of keeping the management and the workmen in touch with each other and in harmonious relations.

It has been customary in the last few years to use the labor turnover as an index of the degree to which the management is successful in keeping in close touch with its employees. At present the labor turnover of manufacturing establishments throughout the country will average in the vicinity of 400 per cent. This, however, takes in all kinds of shops under all varieties of management. The shops which have made conscious efforts to establish better relations are able almost invariably to show a much lower rate of turnover. It has sometimes been said that the only thing our employees want is money. If this were so then the lowest rate of turnover would be in the shipyards and munition plants where the highest wages ever known are being paid. The contrary is true, however, as they are running up to or over the average rate for the country in almost all cases. No one factor can be depended on to diminish this percentage, but all of them working together will surely, as in our own case, cut the labor turnover in quarters if not even more.

One of our activities along this line comes under the head of Employment. This means not merely the selection of the best men from a rather discouraging supply, their physical examination, the placing of them in positions best suited for their physical and mental power, but following them up while they are with us and especially as to the reasons for which they leave us when they do go.

The study of the reasons why men leave is one which almost every concern will find very productive of results, as it often indicates that there is quite a variance between the reasons which are advanced by the foremen and those given by the workmen themselves. If there were only one thing which could be done to better relations between the management and its employees, probably this one of keeping track of the reasons why the men leave would be productive of greater results than anything else. Possibly one of the things which this study is most likely to show is that hours of labor have much less interest to workmen than is sometimes thought; for example, in spite of the fact that on one side of the street we have 200 machinists working on 8-hour shifts, there has been no evidence of a desire on the part of nearly a thousand men on the other side working 10 hours, to secure transfers. In fact the total number of men leaving the Norton Grinding Company to secure shorter hours in the past year is only two.

The second department dealing with employees is the Hospital, and we find it very important that the Employment Department and other employee relations shall keep in the very closest touch with it and its records and advice so that all of these departments practically become one in their purpose and results.

The third department, that of Safety Engineering, has followed out the usual custom of providing mechanical safeguards until now the plant is so well covered that accidents seldom occur which can be traced to lack of mechanical guards. The large problem before the Safety Engineering Department today is that of the education of men in safe practices, by means of bulletins, lectures, moving pictures and other educational means.

Another department quite essential to better relations is that of training. This will be discussed by another speaker so that I need only refer to the fact that we find the labor turnover among men who have been given intensive training much lower than among those who have been thrown into their jobs without preparation for them. No one type of training can be prescribed offhand for all shops and all conditions. In many instances, especially such processes as can be taught in a short time and where increased value comes from dexterity, it is probably better to do the training on the job through foremen especially fitted for that work but without special equipment or separation from the usual work of the shop. On the other hand, where work requires thought,

[1] Employment Manager, Norton Grinding Co.

care and skill as differentiated from dexterity, the vestibule school has been found most acceptable. For work which can be taught on the job but where there is a body of related knowledge which can best be given in the classroom, the continuation school so strongly advocated by the National Association of Coöperation Schools has its value. All of these activities are going on here in this Company and all doing good work.

Other problems which must be faced for the benefit of the employees as well as the profit of the company, include transportation, especially for shops situated as so many are at a distance from centers of population so that means have to be provided for the workmen to get back and forth at a time when the transportation companies are rushed and least desirous of adding to their burdens. This problem has met a partial solution here by the running of two workmen's trains from the center of the city into our yards and by means of a trolley terminal nearby.

The problem of feeding is always with us and is one of the most unsatisfactory of solution of all problems. The line of least resistance is to secure some outside contractor to whom a concession can be given allowing him to feed and profit from the feeding of our employees. Where only one meal per day is served it is difficult to find a contractor who will agree to give real food such as we would wish our employees to eat and expect to make a profit from its sale. We have found it desirable to maintain a lunch room for our office employees which serves a luncheon, and also to maintain various dining rooms for workmen where ordinarily soup, pie, coffee and in warm weather ice cream are sold to the men with which they can supplement the cold food which they bring from home.

In addition to this we have found a great demand for the sale of milk and ginger ale which we have met by the establishment of milk stations in some buildings and milk wagons in others. There is no doubt but that the milk has a greater nutritive value and is the best from the employer's point of view. On the other hand, there are many workmen, especially those working in hot and dusty places, who feel the need of something like ginger ale to clear their throats and send them back to work refreshed.

Wash rooms are another thing which appeal to the men very strongly, and we have accordingly installed an arrangement making it possible for every man to use running water which has not come into contact with any other person. Our lockers are all of full height, which allows a man to wear as good clothes as he chooses and hang them in a way that makes them look acceptable when he takes them out.

You will also be interested in our gardens which are not exclusively a war measure as they have been conducted for several years, always with an increasing number of farmers. These gardens are each about 50 ft. by 75 ft., and are rented at the nominal charge of $1.50 per year to partially cover the cost of plowing and harrowing. This has had a large effect on our labor turnover. Last year, for example, when we had 600 gardens only three gardeners left our employ between the time of planting and harvesting. Under ordinary conditions we have a labor turnover of about 80 per cent, and during practically six months' time it can be seen that out of any given number of men a great many more would normally have left than did actually leave.

All these factors, together with our athletic association, minstrel shows, etc., help to build up a social interest which has a large holding power but which is not the result of any one activity.

VESTIBULE SCHOOLS

J. C. SPENCE, WORCESTER, MASS.

THE munition firms of the United States failed to deliver British, French and Russian contracts on time in 1915 and 1916 simply because there were not enough tool makers in this country to make the jigs and gages for the manufacture of rifles and munitions alone, to say nothing of the increased demand for every other product of our factories, such as machine tools, engines, automobiles, rolling mills and so on, almost without end.

One of the consequences of this sudden demand for men was a ruthless attempt on the part of most of the war-order plants to obtain tool makers and machinists at any cost, and regardless of which going industries were hurt.

The ensuing confusion was augmented by the fact that the American Federation of Labor seized upon this time to send its labor agitators broadcast, with the result that practically no manufacturing center of any consequence, on the eastern seaboard, at least, escaped having very bitter strikes.

The manufacturers of the country were almost wholly unprepared to handle the situation, in so far as shortage of skilled labor was concerned. They had never before been faced by exactly this same problem. They had had keen competition for help several years previous during the very rapid expansion of the automobile business, but nothing that approached this new state of affairs.

Practically the only remedy used by the majority of the struck plants, or plants whose help had left for the "Promised Land" of Bridgeport and New Jersey, was to send out representatives to steal skilled help from towns not yet affected by the fever. All, without exception, followed this practice. The manager who says he did not either failed or else he was not aware of the proselyting carried on by his organization.

The Norton Grinding Company realized in 1915 the uselessness of attempting to hire skilled men in a community crowded with business, and started a Training Department. We have not a true Vestibule School, as such a school is an adjunct of the Employment Department, and is used principally as an examination room for applicants. What we have done is very simple and can be duplicated by any factory practically without cost.

To start a Training Department only two things are necessary:

1 A manager who really wants to help the United States to win this war to the extent that he will do his share of the breaking in of the "rookies" of industry.

2 A workman or foreman who has the knowledge, and especially the patience, to keep everlastingly teaching green help.

The first objection raised by most managers is that they have neither the necessary equipment nor the floor space. This is a natural first thought, but is wrong for this reason: In every department, say, in a machine-tool shop there is a certain amount of simple work to be done. This applies even to the tool room. It is the custom to give this simple work to the less skilled men, and to use the older machine tools, thus allowing the more valuable men to do the better work.

This being so, then why not simply take a lot of these machines, some of every variety, and concentrate them in one department? Some rearrangement of the shop may be necessary, but, on the other hand, this is usually a blessing, as most shops profit by frequent well-studied movings.

Start in a small way, and enlarge as you get experience.

[1] Superintendent, Norton Grinding Co.

Sometimes you will find that you have to overcome a deep-rooted resentment on the part of those foremen and workmen who served a long-term apprenticeship against any "presto, change!" method of producing help. Avoid this by starting small and letting it be thoroughly understood that the school is not intended to produce real machinists, but simply to take from the shoulders of the foreman the hard preliminary work of breaking in inexperienced help.

We do not attempt to make specialists in our Training Department. The student is taught a little of all of the common machine-shop operations, for we do not know in which department he will probably work. We simply wait for the opening to occur, and then the head instructor furnishes the student whom he thinks is best fitted for the job, regardless of the length of time served in the Training Department.

The Training Department runs along as a department of the shop, having its own schedule to meet in the production of simple parts and assembled mechanisms. This schedule calls for about one-half of the available labor of the department, the remainder being picked up throughout the plant in the form of odd jobs. It is really surprising, in times like these, how the foremen of a plant welcome an odd-job department. Here they get rid of all of the one-piece bothersome things that make fine jobs for the beginners, as this kind of work usually calls for the use of several different kinds of machines.

The toolroom also turns over much of its roughing work, as, for instance, the making of milling cutters, taps, reamers, arbors, etc., up to the very final operations that require experienced men.

If, by chance, the Training Department runs low in the right kind of work, that is, work that gives training in many branches of the trade, the head instructor has the right to commandeer any job in the main shop, no matter whether or not his department is equipped to do that job in an economical manner. For instance, if it becomes necessary to get some work to train men in the cutting of threads in an engine lathe, we go so far as to take work away from a turret lathe, even though the resulting threads show on our cost sheets to have cost us ten times what they ought to.

We pay an adult who has had previous experience at some kind of work the prevailing wage for common labor. Just now, in this section, this is 35 cents per hour. With our 55-hour week this amounts to $19.25, which is an inducement for many men, especially as there is the additional advantage of being able to make a good start toward learning the machinist's trade.

About a year ago France made it a law that each factory employing 300 people or more should maintain a separate Training Department.

Great Britain at the outbreak of the war tried to supply help through putting new workers on the machines, as we have always been accustomed to do, but soon found that the great numbers of newcomers swamped the old. The technical schools were resorted to, but they were abstract, academic and unacquainted with production requirements. Then school directors were replaced by factory managers, with foremen in charge of departments under these directors.

Finally British and French manufacturers came to see, as we must now see, that the obligation to produce war products in quantities implies another and equal obligation, i. e., the production by systematic training of mechanics who will produce the war requirements.

The manufacturer who would produce war materials must produce the machinists who will operate his plant. We must prepare to give up thousands of skilled men and make the semi-skilled and the inexperienced replace those we lose. There are not enough skilled workers in the country today to produce anywhere near the war products that we will need.

It is the immediate duty of every essential industry to take hold of the problem of remedying this condition. For the sake of helping our Government, we should have the foresight to do voluntarily what we will probably be finally forced to do by law or necessity. This war is going to last plenty long enough for every essential industry to get back a hundredfold any investment made in such an enterprise.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Departments of The Journal by members of The American Society of Mechanical Engineers are solicited by the Publication Committee. Contributions particularly welcomed are suggestions on Society Affairs, discussions of papers published in The Journal, or brief articles of current interest to mechanical engineers.

More Research Papers Desirable for A.S.M.E. Transactions

TO THE EDITOR:

The writer heartily concurs in the plea of Mr. Sanford A. Moss for more "high-brow" papers for record in our TRANSACTIONS.

Although a decided improvement in the character of American research papers is noticeable of late years, apparently but few of our engineering publications care to consider papers treating technical problems on a mathematical basis.

In Europe the more important research papers attract considerable attention on part of the engineering profession, and the discussions which accompany them are not only of benefit to the author but also serve ultimately to establish a school of engineers highly proficient in some particular field of endeavor. A similar atmosphere in this country would no doubt lead to greater technical interest on the part of our engineers, and at the same time be decidedly helpful in advancing our research technique and bringing it fully abreast of the standard prevailing in Europe.

Meritorious research papers often represent the results of years of investigation and contain an abundance of interesting material that is invaluable to the engineering specialist. Such papers are well worth careful study, as they form a storehouse of original information to which recourse may be had repeatedly as various practical engineering problems present themselves for solution.

The lack of more intense interest in research papers appears to be due to the apprehension with which many of our engineers approach the more intricate mathematical papers, in which concentrated quantitative form one paragraph will often

require page upon page of descriptive matter to be as explicit.

While a few of our larger commercial establishments have fostered research work for their own benefit, the resulting material is generally not accessible to the public. Our public institutions, both state and national, have also made substantial contributions to engineering research work, but these efforts in themselves are hardly numerous enough to effect the rapid advance in scientific progress desired.

It is therefore up to the profession generally to offer greater encouragement to the trained individual investigator who from sheer love of science is ready to devote himself painstakingly to advance the particular phase of research work in which he is especially proficient. The integration of effort on the part of many such workers will surely lead to a far more rapid advancement in the art of scientific research. To bring this work fully abreast of the times, by all means foster the congenial atmosphere that is conducive to the further development of the research abilities of those so inclined.

LOUIS ILLMER.

Boston, Mass.

Conservation of Coal

TO THE EDITOR:

More knowledge regarding the perfect combustion of coal should be acquired by all those who have to shovel it into the mouths of power or heating boilers or furnaces in large institutions and blocks of buildings using many tons each day.

Evening classes should accordingly be maintained by city councils in the schoolhouses, with expert instructors to lecture and demonstrate regarding proper methods of firing to get the best results out of the fuel and produce perfect combustion. Students at such classes should be shown samples of the various grades of coal, the heat value of each being explained, as well as the quantity of air it requires for perfect combustion, etc.

We require men to have an engineer's certificate before we allow them to take charge of a steam boiler, but I have yet to learn that an examination for such embraces the principles of obtaining the best results out of the coal burned to generate the steam. Often men are seen laying a heavy charge of fuel on a bed of incandescent coal too thick to allow the gases from such to be thoroughly mixed with the amount of oxygen supplied. A surplus of air is also frequently noticed with some firemen, who leave the feed doors open longer than they should. It is obvious that this air passing over new fuel is cold and cannot be mixed with the combustible gases; consequently the volatile portions of the hydrocarbons do no useful work. This lowering of the temperature of gases in the combustion chamber and flues is bad enough from the smoke-nuisance and coal-saving point of view, but to my mind a greater evil exists, and that is the unequal expansion and contraction of the boiler shell by such sudden changes of temperature. For a fireman who carries a thicker fire than necessary and then keeps his feed door open to reduce steam pressure is shortening the life of his boiler. A further waste of coal results when the boilers and steam-pipe surfaces are not insulated with asbestos.

If evening classes were established, the men should be informed of the percentage of waste of coal caused through various thicknesses of boiler scale and of flue scale, and, in fact, of all matters relating to getting the best results out of the coal.

The idea prevails that so long as a man is strong and can handle a shovel or firing tools, further knowledge is not required. If an applicant can show that he has fired a steam boiler before, it is taken for granted that he knows his business, regardless of the fact that he may not be acquainted with the rudimentary principles of combustion. If after attending the classes spoken of these men could answer the necessary questions they should be given a fireman's certificate, and as an inducement for them to practise what has been explained to them, they should receive a bonus or percentage on the amount of coal saved. Indeed, I would go further and suggest that all such men should be licensed by the Boards of Trade or similar responsible bodies of our cities if coal is to be conserved in the interests of ourselves and those who come after us.

JAMES S. KINGSTON.[1]

Ottawa, Ont.

WORK OF THE BOILER CODE COMMITTEE

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York City.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in THE JOURNAL, in order that any one interested may readily secure the latest information concerning the interpretation.

Below are given the interpretations of the Committee in Cases Nos. 190-193, inclusive, as formulated at the meeting of May 16, and approved by the Council on June 4, 1918. In this report, as previously, the names of inquirers have been omitted.

CASE No. 190

Inquiry: Can the vertical joint of the inside furnace plate of a Manning boiler be welded by the autogenous process, under the proposed revision of Par. 186 of the Boiler Code as published in the March issue of THE JOURNAL? In the Manning boiler the collapsing pressure on the inside furnace sheet is fully supported by staybolts and this joint is under compression instead of tension.

Reply: It is the opinion of the Committee that if the vertical joint of an internal furnace which is fully supported by staybolts is welded by the autogenous process, it will meet the requirements of the proposed revision of Par. 186.

CASE No. 191

Inquiry: Does or does not Par. 190 of the Boiler Code indirectly indicate that, unless definitely specified, and the specification distinctly stating, tension test sample shall be taken from the plate transverse to the direction of rolling, butt straps shall be cut so that their shorter or transverse dimension shall represent the longitudinal direction of the plate as rolled, in order that the greatest tension stress, the circumferential stress, sustained by the metal, shall be in the direction of the fiber produced by rolling?

[1] Heating and Ventilating Engineer, Chief Architect's Branch, Public Works Department.

Reply: It is the opinion of the Committee that the word "plates" in the fourth line of Par. 190 of the Edition of 1914 with Index refers to shell plates only and not to butt straps. It is proposed to insert the word "shell" before "plates" in the revision of Par. 190 in order to clearly indicate the intent of this rule.

Case No. 192

Inquiry: Is it the intention of the Boiler Code Committee to remove the limitation on the length of headers which may be made of malleable iron for use in connection with boilers under Par. 245? The present edition of the Code appears to limit the length of the header, whereas the proposed revision as published in the March issue of The Journal would remove this limit.

Reply: It is the opinion of the Boiler Code Committee that Par. 245 of the present edition of the Boiler Code does not restrict the length of cast iron or malleable iron headers, but that the limitation as to cross sections applies only to the form and size of the internal cross section, perpendicular to the longer axis of the header.

Case No. 193

Inquiry: Does the word "riveted" which is used in the proposed revision to Par. 273 of the Boiler Code to indicate a method of attachment of a "plate or plates" to the body of a safety valve as an alternate to stamping or casting the markings on the body, prevent the use of screws for the attachment of such plates?

Reply: It is the opinion of the Committee that the requirement for riveting is covered provided the plate is attached to the safety valve by screws with the outer ends riveted over so that the plate cannot be removed.

REVISION OF THE BOILER CODE

The Council of the Society directed that a hearing be conducted in accordance with the recommendation in the Boiler Code that a meeting at which all interested parties may be heard be held at least once in two years to make such revisions as may be found desirable in the Code, and to modify the Code as the state of the art advances. The first of these meetings was held at the Society's headquarters in New York, December 8 and 9, 1916.

The Council also directed that the proposed revisions in the Boiler Code be published in The Journal, with the request that they be fully and freely discussed, so as to make it possible for any one to suggest changes before the Rules are brought to the final form and presented to the Council for approval. This has been done, and the revisions were presented in the March issue of The Journal, pp. 234-247, in the April issue, p. 316, in the May issue, pp. 398-400, and in the June issue, pp. 468-470, in the form proposed for submission to the Council, except as they may be modified by editing without change of sense.

The revisions finally agreed on are those that have been published in the March, April, May and June issues of The Journal, with the modifications which follow. Although these modifications are in a sense final, the Committee would like any one who has an important criticism or suggestion to offer to submit the same immediately to Mr. C. W. Obert, Secretary of the Boiler Code Committee, 29 West 39th Street, New York, N. Y.

May Journal, p. 398

Letter to the Council:

Add the following to the third paragraph relative to the Conference Committee:

The members of the Conference Committee are notified of and invited to attend all meetings of the Boiler Code Committee, and have rendered most useful assistance in preparing the interpretations as well as in coöperating with the Boiler Code Committee in revising the Code.

March Journal, p. 234

Letter to the Council:

Add to the list of names of those constituting the Boiler Code Committee, which follows the letter to the Council, the following:

Conference Committee

(Names to be inserted here)

March Journal, p. 241
and
June Journal, p. 470

Par. 292:

Cancel the entire revision proposed for Par. 292 and replace by the following:

292 No form of device shall be used for controlling the water supply, or the indications of the height of water in a steam boiler, unless it is approved by the state or municipal authorities enforcing these rules.

March Journal, p. 243
May Journal, p. 400
and
June Journal, p. 470

Par. 354:

Cancel revision proposed for Par. 354 in the March and June Journals, so that this paragraph will read as it originally appeared in the Boiler Code.

March Journal, p. 243

Par. 359:

Modify proposed revision of Par. 359 to read as follows:

359 *Double Grate Down Draft Boilers:* In boilers of this type the grate area shall be taken as the area of the lower grate plus one-quarter of the area of the upper grate.

March Journal, p. 243

Par. 363:

Modify the proposed addition to Par. 363 so that it reads as follows:

Temperature Regulator. A temperature regulator which will prevent the water from rising above 210 deg. fahr., shall be applied to all hot water supply boilers irrespective of the working pressure, and to hot water heating boilers in which the working pressure exceeds 30 lb. per sq. in.

March Journal, p. 244
and
June Journal, p. 470

Par. 374:

Cancel revision proposed for Par. 374 in the March Journal and revise it from the form in which it appears in the present edition of the Code by inserting the following after "in." in second line:

"but not to exceed 160 lb. per sq. in."

Add at the end of Par. 374 the following:

The separate sections when tested to destruction shall withstand a hydrostatic pressure of at least 1200 lb. per sq. in.

PAGE 109—APPENDIX

Insert in the Appendix the following:

Where state or municipal authorities allow the use of automatic water gages, they shall conform to the following requirements:

(Insert here rules 1 to 7 as proposed for Par. 292 on page 241 of the March Journal, and revised on p. 470 of the June Journal.)

SOCIETY AFFAIRS

A Record of the Current Activities of the Society, Its Members, Council, Committees, Sections and Student Branches; and an Account of Professional Affairs of Interest to the Membership

PREPARE to Win! was the essential note struck at the Spring Meeting. No longer is it satisfactory to prepare for war—we must prepare to win.

Among the most helpful sessions to the undertaking of the United States in the present war was that on the Conservation of Fuel, under the auspices of the Committee of the Society of which Prof. L. P. Breckenridge is chairman, and attended by the representative men of the nation.

Another feature essential to winning the war is Emergency Technical War Training. The session on this subject was opened by an address by Prof. Arthur L. Williston, chairman of the Society's committee for this important activity. Others who addressed the meeting were Lieutenant André Morize, of the French Military Commission, and Major James E. Cassidy, of the 301st Engineers, an official observer at the front in 1916.

Notwithstanding the intensive war period and the fact that a year ago our Society met in Cincinnati, a central city, and jointly with another large organization, the Machine Tool Builders' Association, the attendance at the Worcester convention was larger than at any previous Spring Meeting, namely 986, of which 472 were members and 514 guests. Whereas the effort was concentrated on Win the War activities, and nothing was allowed to distract our main attention from these features, nevertheless the moments of relaxation were occupied by the wonderful program arranged by the Worcester Convention, permitting the members of the Society to enjoy the delightful friendships they have with our members and friends in Worcester, and to develop new acquaintanceships.

The beautiful scenery in and around Worcester, and the automobile ride to Concord, Lexington and the Wayside Inn, further added to the pleasures of the Spring Meeting.

In the general meeting before the whole Society Mr. Warner and Prof. Kent gave eloquent tributes to Prof. F. R. Hutton, who passed away just previous to the meeting. Prof. Hutton as Secretary for nearly a quarter of a century through its formative period had developed the personal as well as the professional side of the Society's work. In regarding, therefore, the splendid arrangements provided by the Worcester Committee, the ideal as expressed by Prof. Hutton in his Presidential Address for a convention of the Society was fully attained.

The spirit of rendering service which is now uppermost in the minds of all the people had birth quite as early in the engineering societies as in any other group of America's citizens. This is evidenced by the words used last February in the dedication of the new Engineers' Club in Dayton, Ohio, to the "dissemination of truth and the creation of civic righteousness."

One of the secrets of the complete success of the Worcester convention was the fact that it was our members who in their capacity as most active citizens in the drives of the Red Cross, Liberty Loan and Y. M. C. A. in Worcester, were naturally those that were grouped together on the Local Committee for our Spring Meeting, and, having worked out all the activities of these campaigns to a wonderful degree of success, it was to be expected that our convention should attain the same standard.

At the Council Meeting the report of the Special Committee on Readjustment of the Industries for War Work was approved, and a committee authorized to be appointed by the President. It is expected shortly that not only will there be a committee but that there will be regional representatives coöperating with the other instrumentalities of the nation. Dr. Hollis has with especial happiness expressed the idea that this is not an engineers' war any more than it is a financial war; but it is a war in which engineering is greatly employed, and the opportunity for service by our profession and the Society as an instrument of the profession could not be greater.

General March in his remarks to the graduating class at West Point this month stated:

"You are face to face with the most glorious adventure in the history of the world—a modern crusade, where an entire nation, without thought of territorial aggrandizement or of material gain, has planted its standard upon the soil of France in order that freedom shall be guaranteed to posterity. Go in and win!"

CALVIN W RICE,
Secretary.

Council Notes

A WELL-ATTENDED meeting of the Council was held in the Hotel Bancroft, Worcester Mass., on June 4, 1918, in connection with the Spring Meeting of the Society. There were present:

Charles T. Main, *President;* Charles H. Benjamin, Arthur M. Greene, Jr., James A. Hartness, Ira N. Hollis, D. S. Jacobus, George A. Orrok, Charles T. Plunkett, W. R. Warner, W. H. Wiley, *Treasurer;* D. R. Yarnall L. P. Alford, *Chairman of Meetings Committee;* Jesse M. Smith, *Chairman of the Committee on Constitution and By-Laws;* Calvin W. Rice, *Secretary,* and W. E. Bullock, *Assistant Secretary.*

National Research Council. The President announced that in response to the invitation of the Engineering Committee of the National Research Council he had appointed Past-President John R. Freeman to sit with them in the discussion of their mechanical engineering problems.

Spring Meeting, 1919. It was voted to hold the next Spring Meeting in Detroit, Michigan, on a date to be mutually arranged by the Committee on Meetings and the Detroit Local Committee.

Committee on Readjustment of Industries for War Work. The report of this Committee suggesting ways in which the Society might serve the country in the matter of readjusting industries for war work was accepted, and the President was authorized in his discretion to appoint a committee to carry out the recommendations.

Boiler Code Committee. Interpretations of the Committee in cases 190 to 193 inclusive were approved with slight changes and ordered printed in THE JOURNAL. *Replies of the Committee* to communications from Mr. J. A. Hance and from the State Industrial Commission were approved.

Enemy Alien Members. A recommendation to drop from the membership all those who do not comply with the "Trad-

ing with the Enemy" Act, and all alien enemies was referred to the Engineering Council for advice as to what action this Society should take to be in accord with the other Founder Societies.

Communications. The Secretary read a letter from the family of Prof. F. R. Hutton, acknowledging the wreath of the Society and the sentiments it conveyed.

A communication from Sir John A. F. Aspinall expressed his thanks to the Council for its congratulations upon his election to the presidency of the Institution of Civil Engineers.

Quorum of the Council. The following By-Law was approved to take effect immediately after the constitutional amendments to be voted on at the Business Meeting the following day were made: "The number of persons constituting a quorum of the Council shall be one-third the number of members of the Council then in office."

Adjournment was taken to reconvene September 20, or at the call of the chair.

CALVIN W. RICE,
Secretary.

Readjustment of Industries for War Work

PRESIDENT MAIN TAKES IMPORTANT STEP SECURING COÖPERATION OF OUR SOCIETY WITH WAR INDUSTRIES BOARD

FOR the purpose of developing new industrial resources to meet the war demands of the Government, and quickly to disclose additional means of increasing production, the War Industries Board has just established a Resources and Conversion Section. Mr. Charles A. Otis, of Cleveland, former president of the Cleveland Chamber of Commerce and a member of the Board of Directors of the Chamber of Commerce of the United States, has been appointed Chief of this Section.

To carry out the plans of the War Industries Board, it has been decided to divide the country into twenty regional groups and to organize each region through the commercial organizations within the region.

In each of these regions all types of industry represented in the membership of the business organizations and in addition all industries which may not be a part of such membership will be invited to coöperate.

The purpose of this regional system is immediately to make a careful survey of every section of the country to determine what industries not now doing war work may be utilized for such work, and also to ascertain what industries already engaged on work for the Government are able to take on additional contracts or increase their production of munitions and war supplies.

Utilizing our Local Sections organization, President Main has appointed the following members of the Society to act as its representatives on each of the Regional Committees of the Resources and Conversion Section of the War Industries Board:

Bridgeport, Conn........Harry E. Harris
New York City........G. K. Parsons
Philadelphia, Pa........Lewis F. Moody
Pittsburgh, Pa........J. M. Graves
Rochester, N. Y........F. W. Lovejoy
Cleveland, Ohio........F. H. Vose
Detroit, Mich........G. W. Bissell
Chicago, Ill........A. D. Bailey
Cincinnati, Ohio........Fred A. Geier
Baltimore, Md........William W. Varney
Atlanta, Ga........Oscar Elsas
Birmingham, Ala........J. H. Klinck
Kansas City, Mo........J. L. Harrington
St. Louis, Mo........R. L. Radcliffe
Milwaukee, Wis........W. M. White
Dallas, Texas........A. C. Scott
San Francisco, Cal........B. F. Raber
Seattle, Wash........R. M. Dyer
Boston, Mass........A. C. Ashton
St. Paul, Minn........Paul Doty

The President has also created a national committee of our Society on Readjustment of Industries for War Work. Mr. George K. Parsons, the chairman of our committee on this same subject, who was appointed as the outcome of the recent successful meeting of the New York Section on Non-Essential Industries, is chairman of the main committee. The other members of the national committee are F. A. Scheffler and Erik V. Oberg.

The action of President Main is in accordance with the action by the Council at its meeting in Worcester, of carrying out the recommendations of the Committee on Readjustment of Industries for War Work, and the President chooses the above method as the best means of rendering effective service by offering our organization to an agency already established for carrying on the work.

Desirable Constitutional Changes

It has been said that an ideal constitution of a society should "embody organization structural principles only and provide for nothing except members, officers and money." Details should be "left to by-laws." These statements are sound; a society that is not moribund is an elastic thing, and its development should not be hampered by the constitution curtailing future desirable activities.

On the other hand, the interests of a society are the interests of its members and should at all times be conserved and safeguarded by a constitution which limits things which should be limited.

The amendments to our Constitution adopted at the Spring Meeting at Worcester adhere to the principle that a simple constitution is best by reducing the number of constitutional standing committees, or Standing Committees of Administration, from ten to six.

The Standing Committees of Administration are now Membership, Finance, Meetings and Program, Publications and Papers, Local Sections, and Constitution and By-Laws. The former standing committees on House, Library, Research, Public Relations, and Standardization are now transferred to the By-Laws, and more may be added to their number at the discretion of the Council.

Analyzing the effect of these changes on the development of the Society, the six committees in charge of the six major activities now have a representative at all Council meetings to take part in all deliberations. Coördination of these six activities is secured through the contact of these representatives, which occurs under the most advantageous circumstances, simultaneously with the meeting of the governing body of the Society. The new arrangement therefore presents attractive possibilities.

That the members desired the Sections Committee included in the new standing committees of administration is a recognition of the potency of this activity. The Local Sections movement presents practically unlimited possibilities, and every step necessary should be taken which tends toward its full

realization. The Sections Committee has recently taken great strides forward; it has recommended autonomy to the Local Sections, and the autonomy has been approved in principle by the Council and new amendments proposed to the Council.

The changing of the names of the Meetings and Publication Committees to Meetings and Program, and Publication and Papers, is the idea, long since conceived, of the late Professor Hutton, who was a student of the Society's policies and the constitutional provision for them. The new names indicate more clearly the functions of these committees, as they have been in force for some time.

The changes in the methods of the Society's organization are but indications of a desire to harmonize the principles of government and to recognize the will of the membership. They are not even new indications, because ever since the Society was formed, and throughout all its successful development, the interest of the members in these things has been as keen as now. The point is that until recently there has been no opportunity for expression.

That this interest is an ever-present thing is illustrated by an example which it is proper to insert here. For some time past the President has been selecting the regular Nominating Committee for officers in consultation with members selected by groups of the Local Sections. By initiative of the Council itself, which recognized the advantages of the new method, a constitutional amendment was proposed at Worcester which takes this power of appointing the Nominating Committee entirely out of the hands of the President and places it. through the Sections, in the hands of the voting membership.

Report of the Nominating Committee

The following is the report of the Nominating Committee of the American Society of Mechanical Engineers:

The Committee held its first formal meeting at the Hotel Bancroft, Worcester, Massachusetts, on Wednesday, June 5, 1918. The meeting was called to order at 9:30 a. m., and adjourned at 1 p. m. Prof. L. P. Breckenridge was elected chairman.

The following members were present: L. P. Breckenridge, *Chairman*, New Haven, Conn.; Major Thomas E. Durban, Erie, Pa.; William P. Caine, Ensley, Ala.; George R. Wadleigh, St. Louis, Mo. Major C. F. Hirshfeld, Detroit, Mich., was absent but submitted a letter with his nominations.

After carefully considering the names submitted, the following nominations were unanimously approved:

For President:
Dean Mortimer E. Cooley, Ann Arbor, Mich.

For Vice-Presidents:
F. R. Low, New York City.
Henry B. Sargent, New Haven, Conn.
John A. Stevens, Lowell, Mass.

For Managers:
Charles L. Newcomb, Holyoke, Mass.
F. O. Wells, Greenfield, Mass.
Dean C. R. Richards, Urbana, Ill.

For Treasurer:
William H. Wiley, New York City.

As required by the By-Laws, we are submitting with this report the written consent of each nominee to serve if elected.

Respectfully submitted,
(Signed) L. P. Breckenridge,
Chairman of the Nominating Committee.

Society Service

Our Society is constantly supplying information to its members, as well as to other individuals or other organizations, on technical subjects, through the facilities of the Library and the acquaintance of the Secretary and office staff with the individual members and committees throughout the country. It is usually possible to refer such inquiries to specialists, who have always indicated their willingness to supply information to any reasonable extent; and often, indeed, our members put themselves to a great deal of trouble to help other members who may be in need of definite information which they are able to supply.

A case in point is an inquiry which came from India a few months ago with regard to the equipment of a mechanical-engineering laboratory. Through the courtesy of several professors of engineering who had recently equipped laboratories in this country and through helpful suggestions of various firms the desired information was supplied, as indicated in the accompanying letter:

To the Editor:

I thank you and the several firms and individual professors who at your instance have been kind enough to send me valuable information regarding the equipment of a suitable Mechanical Engineering Laboratory. I have thanked the several firms and professors separately.

I shall soon submit figures and specifications for the approval of the University. If the items be included in the next official budget, I shall be able to place orders with the firms or their agents, if any, in India.

Yours very truly,
(Signed) S. Setti.

Malleswaram, Bangalore, India, March 11, 1918.

Dues of Members Being Remitted

Under a provision of By-Law, B 16, exempting from dues any member who has paid dues for 35 years, the following members have been granted such exemption:

Name	Date of Election	Name	Date of Election
Alden, Geo. I.	1880	Hunt, R. W.	1880
Allen, F. B.	1880	Kent, Wm.	1880
Baldwin, Wm. J.	1882	Lanza, Gaetano	1882
Bancroft, J. S.	1880	McEwan, J. H.	1882
Betts, A.	1881	Marx, Henry	1880
Bond, Geo. M.	1881	May, De Courcy	1881
Burdsall, E.	1880	Porter, H. F. J.	1880
Byllesby, H. M.	1882	Sellers, C., Jr.	1882
Clarke, Chas. L.	1882	Smith, A. W.	1880
Cloud, John W.	1880	Smith, G. H.	1881
Cogswell, Wm. B.	1880	Smith, Oberlin	1881
Coon, J. S.	1880	Tallman, F. G.	1881
Cox, J. D.	1881	Thomas, E. W.	1880
Emery, A. H.	1880	Townsend, David	1882
Forsyth, R.	1881	Trump, E. N.	1880
Halsey, F. A.	1882	Warner, W. R.	1880
Herrick, J. A.	1880	Weston, E.	1882
Hollerith, H.	1880	White, J. J.	1880
Howard, C. P.	1880	Wiley, W. H.	1880
Hugo, T. W.	1882	Wood, W.	1880
Worthington, C. C.	1882		

A list is now also being compiled of members who have reached the age of 70 years and have paid dues for 30 years. These are also entitled to the same exemption. This list will be published as soon as possible.

Steam Engineering Training School at Stevens Institute

The Navy Department has designated Stevens Institute of Technology, Hoboken, N. J., as headquarters for the new United States Steam Engineering School for the training of the engineering officers for the U. S. Naval Auxiliary Reserve.

This school is the only one devoted to training engineer officers for steam-engine service, and is a branch of the large training school now located at Pelham Bay Park, N. Y. It is contemplated to make a five-month course for the training of an officer; one month to be devoted to military and ship duties training at Pelham; one month at Stevens to receive the preliminary requirements and duties of an engineer; one month in inspection and repair duties at local shipyards, machine shops and boiler shops; one month at sea in the engine rooms of different types of boats; and one month subsequent training and examination at Stevens.

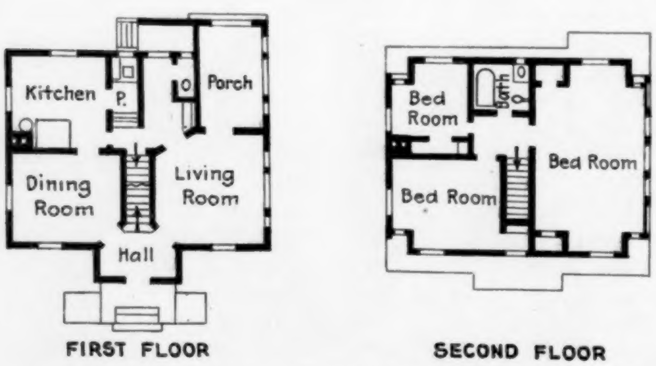
The instructors for the School with the exception of the Civilian Director will be regularly appointed commissioned officers of the United States Naval Auxiliary Reserve and will be selected primarily for their special work.

The school is open to men between twenty-one and thirty, who are physically qualified, of thorough ability and officer-like character, and who have completed the engineering course at any recognized technical school. Any men can enroll with the proper enrolling officer by securing from the draft board a letter of release which in all probability can be obtained for this purpose, provided the men are not included in the current draft quota. A graduate of the School will be commissioned an Ensign in the U. S. Naval Reserve Force.

For additional details application can be made to the Civilian Director, U. S. Navy Engineering School, Stevens Institute, Hoboken, N. J.

Workmen's Model Homes

Those who visited the Indian Hill Community of the Norton Company during the Worcester Meeting were favorably impressed by the architecture of the model houses, designed by Grosvenor Atterbury of New York. For economy of construction and convenience of arrangement these houses could hardly be surpassed, and it will be of interest to JOURNAL readers to see the floor plans of one of the designs, reproduced herewith.



PLAN OF MODEL INDIAN-HILL HOUSE

At the convention of the National Association of Purchasing Agents on May 22, 1918, a resolution was passed advocating the standardizing of the 6 x 9 in. size as a primary standard for catalogs, and the $8\frac{1}{2}$ x 11 in. as a secondary standard.

Lessons From Our Medical Friends

In his presidential address before the American Medical Association, Dr. A. D. Bevan cited some striking facts about the Association, which is recognized as the leader in the organized medical profession of this country. Some of these lessons we might take to heart:

"It is now more important than ever that the admirable activities of the Association should be continued and amplified, and that steps should be taken to meet the new problems that will confront the Association after the war . . . But these things can and must wait on the one great problem that confronts us now, *the winning of the war.*"

"At the outbreak of the war, the American Medical Association offered to the United States government its entire organization and machinery to assist in the enormous expansion that became necessary. Through the officers of the county societies, the state societies, and particularly through the columns of THE JOURNAL, the needs of the government were placed before the organized profession of the country, and they responded splendidly to the call. So far 25,000 have gone into the Medical Departments of the Army and Navy. No other profession or calling has responded more promptly to the needs of the country than the medical profession. The great bulk of the medical men who have gone into government service were members of the American Medical Association."

"The demands made on the medical profession by the war are so great that it is evident that in order to secure the necessary number of medical men for the government, and at the same time prevent hardships in some communities and institutions, it is necessary to organize the entire profession of the country in a systematic way. It therefore became necessary for the American Medical Association, acting with the Surgeon-General's Office, to take a census of the available medical men in the United States in each state, in each country, in each medical school and in each hospital, and to attempt to secure from each one of these different units at least 20 per cent. of the medical men. This plan will enable the government to secure the necessary number of medical officers for an army of 5,000,000 men or more, and a navy of 1,000,000, without any great hardship to any community or to any institution."

"Profiting by the experience of the great nations that entered the war in 1914, the medical profession of the country, and the government, have very wisely taken steps to prevent the disruption of our medical schools, and I am glad to say that our national government adopted the suggestion made by the Surgeon-General to allow medical students to be commissioned in the enlisted Medical Reserve Corps and have them detailed to complete their medical education and to serve a year in a hospital as interns before they are called into active service."

"The United States is the only great reservoir of medical men in the world. The medical professions of Great Britain and France, of Italy and Belgium, and this is probably more true of enemy countries, have been well-nigh exhausted by this war. They delayed making plans for a continued supply, their medical schools became disrupted, and they are already suffering for medical men in their armies and in their civil life."

The Cincinnati Section Committee on Special Training Courses for Women, which consists of George Langen, J. B. Doan and R. T. Hazelton, has requested the Ohio Mechanics' Institute, Cincinnati, O., to give a course in intensive training in mechanical drawing for women. This course will begin on June 24, and it is entirely probable that other courses for women will follow.

AMONG THE LOCAL SECTIONS

THE Sections' Conference at the Worcester Meeting was attended by the following: D. Robert Yarnall, Alex. D. Bailey, Louis C. Marburg, A. L. Rice, W. Herman Greul, G. W. Galbraith, W. C. Brinton, R. Collamore, C. H. Bierbaum, W. W. Macon, G. K. Parsons, G. R. Woods, R. W. Adams, H. P. Fairfield, H. N. Dawes, J. C. Smallwood, A. C. Ashton, L. P. Breckenridge, J. C. Kingsbury, E. L. Fletcher, H. E. Harris, W. P. Caine, E. H. Lockwood, W. G. Starkweather, E. Smith, C. C. Cariss, E. L. Folsom, Calvin W. Rice and E. Hartford, representing in all thirteen Sections.

Mr. W. Herman Greul, Secretary of the New York Section, told in a very interesting manner of the way in which the meetings of the Section were being developed. Supplementing his statement Mr. W. C. Brinton showed a number of slides which gave graphical statistics as to the growth of the membership over a period of years; as to individual grades and total membership. Data was also given as to the attendance figures at the New York Section meetings, showing those attending according to their respective ages and also as to the period of time they had been members. These figures will be further developed and published in a later edition of The Journal. The activities of each of the Sections represented were described in turn by members of the Section in attendance and much of interest and value was developed.

Mr. D. Robert Yarnall, Chairman of the Committee on Sections, told of the recognition being accorded by the Council to the activities of the Sections, and emphasized the big step forward in making the Society truly democratic, through the presentation at the Business Session of an Amendment to the Constitution whereby the voting membership would elect the Nominating Committee, using the organization of the Sections to carry out the election.

The Secretary of the Society and also the Secretary of the Committee on Sections visited a number of the Sections during the month and reported a keen interest in the affairs of the Society in all sections of the country. The Committee on Sections will give considerable attention during the summer to planning for next year's activities and it will thereby be possible to get a flying start in the fall, with a series of meetings of considerable current interest. Likewise a number of new Sections are contemplated and the members in districts where Sections are not now organized are encouraged to develop interest in a Section in their respective localities. The Committee on Sections will be glad to contribute assistance.

Duluth Engineers at Get-Together Dinner

The engineers of Duluth, Minn., have taken the first steps to form a Duluth Engineers' Club by meeting at a get-together dinner on the evening of May 20th, at the Kitchi Gammi Club, Duluth.

At present Duluth has no club embracing all engineers. About thirty years ago a movement to organize was initiated but was not completed. The city has many other representative clubs and ranks high among other cities of the country for its activities and discussions of public questions. The environment is splendid for the growth of an engineers' organization. There are within reasonable distance of Duluth, over a hundred members of the four large national engineering societies, a number of members of the lesser engineering societies and many non-members. Until the successful formation of the Duluth Association of Civil Engineers about three years ago, these engineers had no common ground of meeting, no means to render their united thought effective on questions concerning the welfare of the profession or to promote the civic activities of their skill.

The Duluth Association of Civil Engineers, however, can and does represent only a small part of the whole body of trained technical men. Something bigger and broader is needed. With this view in the minds of the Civil Engineers, the Duluth Association in March, 1917, appointed a committee of Mr. W. H. Hoyt, Mr. W. B. Patton and Mr. W. H. Woodbury to develop a plan for a Duluth Engineers' Club. This committee has studied the situation carefully and is now ready to help in the development.

Its first important move was the call sent out for the above dinner to all members of the four main national engineering societies who lived within suitable distance of Duluth to attend and take part in the discussion. Some seventy engineers were present and took an active interest in the movement. Favorable responses were received from others who could not be present during the evening. The committee prepared an excellent program of talks and lantern slide pictures.

President F. E. House of the Duluth & Iron Range Railroad and retiring President of the Duluth Association of Members of the American Society of Civil Engineers, acted as toastmaster. In opening the program, he briefly outlined the objects of the meeting, and called on Mr. W. H. Woodbury to outline the plan of the formation of an engineering club. Three objects of the club were given by him; first, professional; second, social; third, civic. Four plans of membership have been considered: first, to have an organization for all professional engineers, junior engineers and associates, with different status for each; second, an organization made up of members of the four big national societies; third, an organization of members and a limited number of associates; and fourth, professional engineers only, all on an equal standing.

Mr. W. H. Hoyt reported preliminary suggestions for arranging a home for the club.

Acting on a resolution offered by Mr. T. W. Hugo, Emeritus Member of the American Society of Mechanical Engineers, that steps should be taken to form an engineers' club in Duluth and that a committee be appointed to develop the plan, Mr. House appointed a committee of eight representative engineers as follows:

American Institute of Electrical Engineers:
W. N. Ryerson, *Chairman*, Walter F. Schwedes.
American Institute of Mining Engineers:
Edwin J. Collins, Walter C. Swart.
The American Society of Mechanical Engineers:
Oscar B. Bjorge, W. H. Gallagher.
American Society of Civil Engineers:
W. H. Hoyt, W. H. Woodbury.

It is hoped that this committee will make such progress that another meeting can be called very shortly to put into effect their decisions.

While it is recognized that engineers are busy with war activities and responsibilities, it is felt that this is the time to unite the whole profession in one effective body promoting the interests and welfare of the profession and rendering service to the community. War has shown the great responsibility and opportunity of engineers to direct and do the work of the nation. The progress made by the national engineering societies in unifying their efforts toward securing the proper recognition and employment of their talents to the fullest degree has been reflected by many cities in the formation of strong, well-conceived engineers' clubs. Duluth has a large list of engineers of high standing as individuals and the leaders of the movement for a club are very optimistic of the strength and success possible.

The program of the night included addresses by men of nationwide reputation in the engineering field: Dean John Allen of the College of Engineering of the University of Minnesota spoke on the heavy call for engineers, the depletion of the numbers of students attending the universities and the thinning of the ranks of their instructors. He urged upon the engineers present, the necessity of encouraging young men to take up engineering studies in order that deficiencies in numbers of engineers may be prevented.

Mr. Calvin W. Rice, National Secretary of The American Society of Mechanical Engineers, brought greetings from his Society to the engineers of Duluth, and also read a telegram from the American Institute of Electrical Engineers expressing good will for the organization of a club and hoping their members would take an active part as well as form a local branch of the Institute. Mr. Rice's talk was full of eloquent appeal to the engineers to take up the work and place on its banner the idea of high service for the general welfare of the commonwealth and profession. He set forth that it is for the engineers of America to render the loftiest expression of its objects in the organizing of any technical society.

Mr. Kirby L. Strickland, erecting manager of the American Bridge Co., Chicago, gave a talk illustrated with lantern slides on the Union Pacific Railway Company's new bridge over the Missouri River at Omaha.

Mr. Richard Khuen, Jr., member of the Board of Direction of the American Society of Civil Engineers, and who had a hand in building the famous Hell Gate Bridge at New York, described the work and with lantern slides illustrated the construction in a very interesting manner. A moving-picture film was used to show further how the job was arranged.

Section Meetings

BALTIMORE

May 22. At the final meeting of the Section the following officers were elected: A. E. Walden, chairman; Wm. L. DeBaufre, vice-chairman and A. G. Christie, secretary-treasurer.

The address of the evening was delivered by W. H. Blood, Jr., of the American International Shipbuilding Corporation, on Hog Island, the greatest shipyard in the world.

The speaker called attention to conditions at the outbreak of the war and showed the steps that led up to the undertaking of the Hog Island enterprise. He explained in detail the relations of the Corporation and the Government and showed clearly that the undertaking had been grossly misrepresented in many statements appearing in print. He then discussed the difficulties in construction last winter and how in spite of all the yard was well ahead of schedule. The speaker next took up a discussion of many of the yard's details and impressed his hearers with the immensity of the undertaking.

The address was illustrated by lantern slides showing all stages of construction. These were very impressive.

Another paper by Charles R. Schmidt on The Coal Problem was handed to the Secretary. On account of the lateness of the hour, it was decided to read this by title only, to be taken up at a meeting next fall.

A. G. CHRISTIE,
Section Secretary.

BIRMINGHAM

May 16. The Atlanta Section were the guests at the Annual Meeting of the Birmingham Section. A very enjoyable and instructive inspection trip was made to some of the large plants in the district. Leaving the Tutwiler Hotel at nine o'clock the party proceeded to the plant of the Hardie-Tynes Manufacturing Co., manufacturers of marine engines, and the party witnessed the manufacture of what is known as 1-lb. naval shells. A small section of the plant is devoted to the manufacture of these shells, where they turn them out at the rate of about 2,000 per week.

From the Hardie-Tynes Manufacturing Co., the party proceeded to the plant of the Birmingham Machine & Foundry Co., principally engaged at this time in the manufacture of 14-in. semi-steel naval practice shells and also large cotton compresses. Here was seen the largest boring mill in the Birmingham district; a mill of 16-ft.-diameter table, and at the time of inspection this boring mill was working on a large cotton compress platen weighing approximately 60,000 lb.

A trip was then made to the plant of Joubert & Goslin who make large castings for evaporators used in the sugar-refining industries.

After leaving Joubert & Goslin's the party arrived at the plant of the American Cast Iron Pipe Co. A trip through the company's industrial village for negroes known as West Acipco disclosed the fact that they are second to none in welfare work. This village has paved streets, stone and sanitary sewerage and numerous houses with large garden lots for their negro employees. All the houses are of different design, have plastered walls, are equipped with hot and cold water and, in fact, modern in every respect. A picture was taken of the group, numbering approximately 30, at the plant of the American Cast Iron Pipe Co. in front of their modern office building. The entire process of manufacturing pipe was noted at this plant and also the manufacture of large castings for the Air Nitrates Corporation at Sheffield and the experimental 8-in. semi-steel high-explosive shells. A dinner was then served at the Y. M. C. A., which is controlled and operated by the American Cast Iron Pipe Co.

PICTURE TAKEN OF THE GROUP AT THE AMERICAN CAST IRON PIPE COMPANY'S PLANT

In the afternoon the party proceeded to the Ensley Works of the Tennessee Coal, Iron & Railroad Company, where an inspection was made of the steel mill and furnaces.

At eight o'clock the party assembled at the Tutwiler Hotel for dinner and a business session. Mr. Klinck, Chairman of the Birmingham Section, after giving the Atlanta Section a hearty welcome, delivered a short talk on the achievements of the Section during the past year. Mr. Scott, Chairman of the Atlanta Section, in response, thanked the Section for the hospitalities extended and the very enjoyable inspection trip. He also extended an invitation to the Birmingham Section to visit Atlanta either this fall or next spring, and expressed the hope that the Baltimore, Birmingham, New Orleans and various other sections in close proximity could be induced to meet together in Atlanta at that time.

Vice-chairman W. F. Caine gave a short talk and pledged his best efforts in making the ensuing year count a great deal for the Section. Mr. Caine read a letter from the Detroit Engineering Society enclosing a copy of resolutions recently passed by that Society urging colleges and manufacturers to coöperate in the training of women to take the place of men in our industries. It was brought out in discussion that this was an excellent idea and that a great deal rested upon the patience of heads of departments in the manufacturing plants towards the successful training of women, and that whereas they would get their preliminary training in the college, their special training would naturally be obtained

after taking their place in the ranks of industry. It was voted that the resolutions submitted by the Detroit Engineering Society be adopted by the Birmingham Section and that publicity be given these resolutions and an effort made to bring about coöperation and the establishment of places of training for women.

Major F. H. Wagner, O. O. R. C., of the United States Army, who is engaged in work for the Air Nitrates Corporation, delivered a very interesting address on some of the problems that were being worked out in connection with the fixation of nitrogen. He brought out the fact that while detailed information could not be given at this time, when the war is over the engineers will be supplied with very interesting and helpful data on the various achievements that are now being made.

The Section was honored by having as a guest Secretary Calvin W. Rice, who made a most interesting and helpful address on various timely topics, as Unused Water Power, the Training of Women for Industrial Work, Liberty Motors, Gas Warfare, Coöperation in the Engineering Profession, the work of the Engineering Societies, the Dilution of Labor, etc. The main idea of his talk was to furnish food for thought and stimuate the Section in progressive lines and lofty ideals.

W. L. ROUECHE,
Section Secretary.

BOSTON

May 29. The Annual Meeting of the Boston Section was held at the Engineers' Club. After brief reports of the Executive Committee, the following were elected for the year 1918-1919 to serve on the Executive Committee: Geo. P. Aborn, Albert C. Ashton, Wm. W. Crosby, Edward M. Jennings, Elmer Smith and Wm. G. Starkweather.

President Charles T. Main and Past-president Ira N. Hollis were present and addressed the meeting, the latter giving some very interesting data on the fuel situation in Massachusetts. Mr. Ashton then told of the work accomplished by the Boston Section during the year, and the successful meetings which had resulted.

An eloquent and forceful address was delivered by Doctor Charles H. Eaton on America at the Gateway of Destiny. An enthusiastic audience of about one hundred persons listened to this address and later enjoyed light refreshments.

W. G. STARKWEATHER,
Section Secretary.

CONNECTICUT SECTION

Meriden Branch

May 17. The annual meeting of the Meriden Branch of the Connecticut State Section was held at the Winthrop Hotel.

The entire list of officers were renominated by the special nominating committee, and were unanimously reëlected, as follows: C. K. Decherd, chairman; C. N. Flagg, secretary-treasurer; F. L. Rowntree, J. A. Hutchinson and Fred L. Wood.

Mr. R. W. Millard was the speaker of the evening and took for his subject "The Need of Systematic Training and Instruction of Workmen in the Factories." It was the sense of the meeting that a special committee should be appointed for this matter.

The experiences of the various members present, with Government work, was next discussed.

C. N. FLAGG,
Branch Secretary.

ERIE

May 3. The following officers were elected for the year 1918-1919 on the Executive Committee of the Section: M. W. Sherwood, chairman; C. M. Spalding, vice-chairman; R. Conrader, treasurer and J. St. Lawrence, secretary. Following the business meeting Mr. James Burke, Mem.Am.Soc.M.E., gave an interesting talk on The Conservation of Material.

M. E. SMITH,
Section Secretary.

MILWAUKEE

June 12. At a meeting of the Engineers' Society of Milwaukee, Mr. H. M. St. John of the Testing Laboratory of the Commonwealth Edison Co., delivered an illustrated lecture on Products of Electric Furnaces and the Cost of Their Production.

FRED H. DORNER,
Section Secretary.

NEW YORK

May 21. Under the chairmanship of George R. Woods, the subject of the meeting was a timely one on Labor Turnover, and was presented by speakers of prominence representing makers of ships, aeroplanes, ordnance and machine tools.

The first speaker, J. J. Pearson, outlined his work in the British Ministry of Munitions, and his labor-dilution service. Then Orrin W. Sanderson, Director of Labor of the B. F. Goodrich Co., outlined his work in that field, having to do with twenty thousand employees.

Mr. Dudley Kennedy, of the American International Shipbuilding Corporation, and who has charge of the shipbuilding plant at Hog Island, told of the methods employed in that work. Mr. H. F. J. Porter, consulting industrial engineer, outlined the broad principles of the work involved by the operations of the previous speakers. The specialized work that has been done to improve the labor problem was covered by the following speakers: John Calder, of the Aero Marine Plane & Motor Company, at Keyport, N. J., who spoke of the effect of the selective draft; Capt. Boyd Fisher, of the Ordnance Department, U.S.A., who told of the work carried on by the Government in the training of employment managers, and following him L. D. Burlingame, industrial superintendent of the Brown & Sharpe Manufacturing Company, outlined the work of his company in training women for employment. Mr. H. E. Miles, of the Council of National Defense, described the plans and accomplishments of the Council of National Defense to assist manufacturers to train women in their shops.

Major E. N. Sanctuary of the War Service Exchange of the Adjutant General's Office, and other representatives of the Government including the following joined in the discussion: Capt. J. J. Swan of the Committee on Classification of Personnel in the Army, and Mr. J. B. Densmore, Director of the U. S. Employment Service, for the Labor Department.

Mr. G. K. Parsons presented the following resolution which was adopted:

Resolved, That the Chair appoint a Committee to take immediate action to determine how the Society can render the greatest assistance in the solution of the problem of labor turnover.

W. H. GREUL.
Section Secretary.

NEW ORLEANS

June 10. At the last meeting of the Louisiana Engineering Society Mr. Howard Egleston, Civil and Industrial Engineer of the New Orleans Association of Commerce, delivered a paper on The Present Situation as Relating to the Introduction and Use of Natural Gas in New Orleans. The speaker described briefly the natural-gas wells which have been successfully operated at Terrebonne Parish about forty miles from New Orleans. One of the wells is said to have the largest flow of any natural-gas well in the world. At present the chief obstacle of piping this gas to New Orleans is the difficulty of securing the steel for the pipe line, but mention was made of the possibility of using other material such as cast iron or reinforced concrete.

H. L. HUTSON,
Section Chairman.

ONTARIO

May 27. At the Annual Meeting of the Ontario Section which was held at the Engineers' Club, Secretary Calvin W. Rice gave a very interesting talk on the activities of the Society.

Mr. J. H. Billings, Assoc.-Mem.Am.Soc.M.E., delivered a paper on Strength of Cast Iron in Bending as Affected by Variations in Cross Sections.

The results of the election of new members for the Ontario Section were announced as follows: R. W. Angus, chairman; C. B. Hamilton, secretary; James Milne; J. H. Billings and H. B. Ahara.

CHESTER B. HAMILTON, JR.,
Section Secretary.

Student Branch Meetings

Members of Student Branches are requested to notify the Secretary of any change in address as promptly as possible, in order to facilitate delivery of The Journal.

BUCKNELL UNIVERSITY

May 8. The following officers were elected for the ensuing year: G. F. Jammer, chairman; H. R. Pars, vice-chairman; H. J. Hann, secretary and B. J. Wilson, treasurer.

Professor Burpee delivered an interesting address on What Is Expected of the Engineering Student at Present.

H. J. HANN,
Branch Secretary.

UNIVERSITY OF CALIFORNIA

April 24. The election of officers for the ensuing year was as follows: J. Mora Moss, Jr., chairman; E. S. Smith, Jr., vice-chairman; G. C. Goldwaithe, secretary, and A. O. Montijo, treasurer.

A paper was presented by Llewellyn Boelter on The Tungar Rectifier.

LLEWELLYN BOELTER,
Branch Secretary.

CARNEGIE INSTITUTE OF TECHNOLOGY

May 4. The annual banquet of the Branch was held in connection with the last meeting of the year. The following officers were elected for the ensuing year: H. D. Krummell, chairman; W. J. Blenko, vice-chairman; D. C. Saylor, secretary and P. D. Wersant, Jr., treasurer.

Mr. W. C. Bates, of the Fawcus Machine Co., gave an interesting talk on the automatic control of the torpedo, and showed how the Allies and Germany are striving for superiority, each enjoying brief periods of supremacy, which are soon annulled by a new invention which counteracts this temporary advantage.

Professor Trinks gave a short talk on the early days of the Institute, and several of the alumni present also spoke briefly about their experiences since graduation.

H. D. KRUMMELL,
Branch Secretary.

UNIVERSITY OF CINCINNATI

May 23. The following officers were elected for the ensuing year: L. C. Smith, chairman; H. Dangel, vice-chairman and G. H. Eilers, secretary-treasurer.

Mr. J. F. Pflum of the Heald Grinding Co., delivered an interesting paper on Time Allowances for Internal Grinding. Many samples of work were shown and time studies taken were discussed.

Professors Jenkins, Joerger and Shine briefly discussed accurate working limits.

C. L. KOEHLER,
Branch Secretary.

UNIVERSITY OF COLORADO

May 2. The following officers were elected for the ensuing year: R. F. Hamilton, chairman; W. K. Gray, vice-chairman and H. H. Herman, secretary-treasurer.

HARRY H. HERMAN,
Branch Secretary.

UNIVERSITY OF ILLINOIS

During the last semester one meeting each month has been given up to the University War lectures for the College of Engineering. These lectures are intended primarily for engineers, and all of the engineering societies are devoting one meeting a month to the lectures. Subjects of national interest at this time are presented by men well qualified to speak upon the various subjects discussed. The members of the Student Branch feel that it is well worth while to forego one meeting of the Branch by itself in order to hear these lectures.

In addition to talks and lectures by faculty men, and other professional men, the Branch is at this time having a series of talks by student members. Pi Tau Sigma, a professional mechanical-engineering fraternity at the University, offers each year a prize to the student member of the Branch giving the best talk on some technical or semi-technical subject before the Branch. A great deal of interest is shown in this contest, and some very good papers have been presented. A prize is offered to each of the four classes, in order to prevent unfair competition. The Branch has voted to send the best paper of the whole set to the parent Society to be entered in competition for the prize offered for the best student paper from all Student Branches.

C. Z. ROSECRANS,
Branch Secretary.

LOUISIANA STATE UNIVERSITY

May 7. A very interesting talk was delivered by Mr. Etheredge on the manufacture of sugar in Louisiana, in which he pointed out the difficulties to be overcome in using cane bagasse as fuel. Many lantern slides of the different kinds of machinery employed by the various refineries were shown.

May 29. The officers elected for the ensuing year are as follows: C. R. Strattman, chairman; C. R. Byrd, vice-chairman; C. Colomb, secretary and J. A. Scheuermann, treasurer.

A brief talk was given by Mr. Taddicken, of the Westinghouse Co., on the apprenticeship work in large shops.

C. R. STRATTMAN,
Branch Secretary.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

The annual election of officers resulted in the election of the following: Charles A. Chayne, chairman; Scott H. Wells, vice-chairman; Everett F. Doren, treasurer and Edward F. Pierce, Jr., secretary.

STUART H. CALDWELL,
Branch Secretary.

UNIVERSITY OF MICHIGAN

April 30. The following officers were elected: D. M. Ferris, chairman; S. T. Huette, vice-chairman; and A. D. Althouse, secretary-treasurer.

A. D. ALTHOUSE,
Branch Secretary.

MICHIGAN AGRICULTURAL COLLEGE

May 16. The following officers were elected for the ensuing year: A. E. Downer, chairman; E. Osborne, vice-chairman and E. C. Hoch, secretary-treasurer.

H. M. SASS,
Branch Secretary.

UNIVERSITY OF MINNESOTA

March 23. The following officers were elected for the ensuing year: G. H. Brennan, chairman; H. A. Abrahamson, vice-chairman; A. Baker, corresponding secretary; R. M. Foltz, recording secretary and M. S. Wunderlich, treasurer.

A very interesting talk was given by Prof. J. J. Flather, on Ancient Shipbuilding in which he discussed the most ancient forms of ships and the methods used in building them.

May 4. An open meeting was given at which Melvin Ovestrud, of the class '14 now in the employ of the Minneapolis Steel Machinery Co., gave an illustrated lecture on Shell Manufacturing.

A. BAKER,
Branch Secretary.

UNIVERSITY OF MISSOURI

April 25. A paper on The Poppet-Valve Engine was presented by R. T. Powers in which he pointed out the utility of the poppet valve in connection with high steam pressures and the application of this type of valve to the unaflow engine, the high pressures permitted and resulting high economies attained.

May 10. The following officers were elected for the ensuing year: Will Copher, chairman; K. K. King, corresponding secretary and Roy H. Jaeger, secretary-treasurer.

Mr. F. C. Hussey presented an interesting paper on The Manufacture of Dynamite in which the various operations of dynamite were fully explained.

J. W. BALDWIN,
Branch Secretary.

UNIVERSITY OF NEBRASKA

May 11. A business meeting was held which resulted in the election of the following officers for the ensuing year: V. E. Kauffman, chairman; W. L. Millar, secretary; Harvey Glebe, treasurer and L. F. Seaton, honorary chairman.

W. L. Millar,
Branch Secretary.

OHIO STATE UNIVERSITY

May 8. This meeting took the form of a banquet which was followed by the election of officers for the ensuing year. The following were elected: F. H. Cover, chairman; H. R. Ansel, secretary and V. Darnell, treasurer.

F. E. Smyser,
Branch Secretary.

UNIVERSITY OF OKLAHOMA

April 11. After a brief business meeting the following short talks were given: Advantages of High Pressure and Superheat by E. H. Reeves; Comparative Economy of Turbines and Engines by L. A. Humphries; Comparison of Different Means of Power Transmission by F. E. Waterfield; Oil versus Coal Under Boilers by R. V. Goodknight; Feedwater Heaters and Economizers by G. L. Barker; Injector, Rotating and Reciprocating Pumps for Boiler Feed by T. J. Bode; Types of Condensers and Their Economy by B. P. Stockwell and Boiler Explosions by C. D. Reasor.

May 7. The following officers were elected for the ensuing year: Geo. L. Barker, chairman; E. K. Warterfield, secretary and Theo. J. Bode, treasurer.

Talks were given on the following: Keokuk Power by B. P. Stockwell, Sioux and Fox Indians by Don Whistler and Emergency Motor-Truck Driving by E. H. Reeves.

B. P. Stockwell,
Branch Secretary.

UNIVERSITY OF PITTSBURGH

John F. Baker, the president for next year, delivered a brief talk on the aims of the Engineering Society for next year. An interesting address was then delivered by S. H. Orr on The Conditions Affecting the Coal Supply for Next Winter. Several valuable suggestions were made on the conservation of the fuel supply and the efficient operation of power stations. After discussion by the various members of the Branch the rest of the meeting took the form of a social.

John H. Allison,
Branch Secretary.

RENSSELAER POLYTECHNIC INSTITUTE

April 11. The following officers were chosen for next year: Robert I. Todd, chairman; James F. Dewey, vice-chairman; Chester G. Bragaw, secretary and Justin L. Smith, treasurer.

Professor Greene gave an illustrated talk on Mechanical Stokers showing the various types of stokers in general use.

Professor Daugherty then delivered a talk on Photography, explaining in detail the development of the camera from the pinhole type to its present form and by means of blackboard diagrams illustrated the different lenses and their defects.

Chester G. Bragaw,
Branch Secretary.

STEVENS INSTITUTE OF TECHNOLOGY

The following officers were elected for the ensuing year: G. H. Spencer, chairman; H. E. Beaven, vice-chairman and L. V. Aquadro, secretary-treasurer.

Lincoln V. Aquadro.
Branch Secretary.

UNIVERSITY OF WASHINGTON

May 14. The election of new officers was held with the following results: Fairman B. Lee, chairman; Corwin P. Rummel, vice-chairman; Ernest E. Bissett, secretary; Thomas R. Gunn, corresponding secretary and Lester R. McLeod, treasurer.

H. B. Sallee,
Branch Secretary.

ROLL OF HONOR

Angell, Harry J., Candidate, Engineer Reserve Officers' Training Camp, Camp Lee, Va.

Bernard, Harold B., Coast Artillery Corps, N. A.

Blake, A. D., Captain, Ordnance Officers' Reserve Corps, Engineering Bureau, Ordnance Dept., U. S. Army.

Boyer, George H., First Lieutenant, Ordnance Officers' Reserve Corps, U. S. Army.

Blakeman, S. P., Private, 34th Squadron, 3d Prov. Regiment, Science and Research Division, Aviation Section of the Signal Corps, Waco, Tex.

Bosnian, Luther H., Sergeant, Ordnance Department, U. S. Army, Watervliet Arsenal, N. Y.

Brown, Claude C., Master Engineer, Senior Grade, 434th Engineers, Camp Kearny, Cal.

Clarke, Leon L., Captain, Engineer Officers' Reserve Corps, American Expeditionary Forces, France.

Corey, Thomas H., Lieutenant, U. S. Naval Reserve Force.

Durban, Thomas E., Major, Ordnance Officers' Reserve Corps, Ordnance Department, U. S. Army.

Durley, Richard J., Captain, British Army, Imperial Ministry of Munitions, Ottawa, Canada.

Fellers, William M., Lieutenant (Junior Grade), U. S. Naval Reserve Force, Aeronautic Aide, Naval Air Station, Hampton Roads, Norfolk, Va.

Flewelling, Milton F., Candidate, Officers' Training School, Naval Auxiliary Reserve, Naval Training Station, Pelham Bay Park, N. Y.

Haines, Philip G., Co. E, 112th Regiment, U. S. Engineers, American Expeditionary Forces, France.

Hathaway, H. K., Lieutenant-Colonel, Ordnance Department, N. A.

Hayward, H. S., Lieutenant (Junior Grade), U. S. Naval Reserve Force.

Hill, Dudley M., Private, Co. 4, Coast Artillery Corps, Fort Howard, Md.

Hoffman, J. Roy, Aviation Section of the Navy, Massachusetts Institute of Technology, Boston.

Hott, Frank W., Lieutenant, Co. C, 6th U. S. Engineers, American Expeditionary Forces, France.

Jarrett, Hillard W., Chief Quartermaster, Naval Aviation, Inspection duty, U. S. Navy.

Kemble, Parker H., U. S. Marines.

Lance, C. C., Lieutenant, Engineer Officers' Reserve Corps, Co. 5A, Engineer Reserve Officers' Training Camp, Camp Lee, Va.

Le Valley, John R., Ensign, U. S. Naval Reserve Force, Annapolis, Md.

Malone, George B., Captain, Engineer Officers' Reserve Corps, 1st Regiment Replacement troops, Engineers' School, Washington Barracks, Washington, D. C.

Magill, F. R., Sergeant, School of Motor Transportation, Camp Holabird, Baltimore, Md.

Matthew, Robert M., Private, Co. A, 30th Regiment Engineers, American Expeditionary Forces, France.

Moody, Frederick H., Captain, Infantry Depot, 116th Battalion, Canadian Infantry, England.

Morrison, Barrett W., Sergeant, Battery A, 1st Battalion, 1st Brigade, Field Artillery, Camp Jackson, S. C.

Newby, H. L., Private, Aviation Section of Signal Corps, Aviation Camp, Waco, Tex.

Nicoll, William L., First Lieutenant, Quartermaster Officers' Reserve Corps, office of Director of Storage and Traffic, Washington, D. C.

Penrod, E. B., Meteorological Section, Signal Corps, U. S. Army.

Pettis, John G., Chief Machinist's Mate, Aviation Section, U. S. Navy.

Poirier, Austin E., First-class Private, Meteorological Section of the Aviation Section of the Signal Corps, 3d Regiment, 33d Squadron, Waco, Tex.

Porter, Raymond E., Aviation Section of Signal Corps, U. S. Army, assigned to the Aviation Course, Massachusetts Institute of Technology.

Ritter, Ralph B., Second Lieutenant, Field Artillery, National Army, Camp Jackson, S. C.

Rowe, Harold E., Private, Troop B, 303d Cavalry, Camp Stanley, Tex.

Russell, Troy, Private, Co. C, 341st Machine Gun Battalion, 89th Division, American Expeditionary Forces, France.

Semans, F. Wendell, Second Lieutenant, Aviation Section, Signal Officers' Reserve Corps, Ellington Field, Houston, Tex.

Spencer, O. G., Captain, 9th Battalion, 20th Engineers, American Expeditionary Forces, France.

Spice, C. G., Captain, Ordnance Officers' Reserve Corps, Gun Division, Washington, D. C.

Viedt, H. B., Candidate, Officers' Training School for Steam Engineers, Naval Auxiliary Reserve, Naval Training Station, Pelham Bay Park, N. Y.

Voos, Fred W., Cadet, Officers' Artillery Training School, American Expeditionary Forces, France.

Wade, Alfred D., Headquarters Troop, 78th Division, Intelligence Section, American Expeditionary Forces, France.

Wainwright, A. V., Lieutenant, U. S. Naval Reserve Force, Bureau of Steam Engineering, Navy Department.

PERSONALS

IN these columns are inserted items concerning members of the Society and their professional activities. Members are always interested in the doings of their fellow-members, and the Society welcomes notes from members and concerning members for insertion in this section. All communications of personal notes should be addressed to the Secretary, and items should be received by July 15 in order to appear in the August issue.

CHANGES OF POSITION

ROYCE L. BEERS has severed his connection with the U. S. Radiator Corporation, of Detroit, Mich., to enter the engineering department of the Bailey Meter Company.

GEORGE A. ARMES, formerly engineer-in-chief, Union Iron Works Company, San Francisco, Cal., has become associated with the Moore Shipbuilding Company, Oakland, Cal.

CHARLES D. CROSS has entered the employ of the Machinery Utilities Company, Inc., New York. He was until recently connected with the N. Y. C. R. R. Company, New York, in the capacity of assistant night foreman.

BURT C. WEAR, formerly identified with the Tube Company, Lorain, Ohio, in the capacity of estimator, has become affiliated with the ordnance department of the U. S. S. Corporation, Ambridge, Pa.

GEORGE P. SONN, until recently engineer with the Bridgeport Brass Company, Bridgeport, Conn., has accepted a similar position with the National Conduit and Cable Company, Hastings, N. Y.

L. K. SILLCOX has assumed the position of master car builder of the Milwaukee Shops of the Chicago, Milwaukee and St. Paul Railway Company. He was formerly mechanical engineer with the Illinois Central Railroad, Chicago, Ill.

NORMAN G. REINICKER is no longer connected with the New York Edison Company, as assistant to chief engineer, having become associated with the power department of the Du Pont Engineering Company at Nashville, Tenn.

K. M. IRWIN has resigned his position with the betterment division of the Stone and Webster Engineering Corporation, Boston, Mass., to take a position with Perry Barker, fuel engineer of the same city.

HARRY V. HUNT, until recently general superintendent of the Consolidated Press Company, Hastings, Mich., has assumed the duties of general manager of the O'Neil Iron Works, Buffalo, N. Y.

ARTHUR S. ROBINSON has left the employ of the Hyatt Roller Bearing Company, Harrison, N. J., and has become affiliated with the Naval Aircraft Factory, League Island, Philadelphia, Pa., in the capacity of engineer.

MAURICE F. RICHARDSON, formerly plant manager of the Arlington Company, has assumed the position of manager of the Easton Car and Construction Company, Easton, Pa.

HENRY CAVE has left the employ of the Davis-Bournonville Company, Jersey City, N. J., where he held the position of director of technical research, and has become production manager of the S. K. F. Ball Bearing Company, of Hartford, Conn.

WILLIAM A. DREWETT, superintendent of the M. T. Davidson Company, Brooklyn, N. Y., has assumed the duties of vice-president and general manager of the Providence Engineering Corporation, Providence, R. I.

RAYMOND A. COLE, formerly engineer with Robert T. Pollock Company, Boston, Mass., has entered the employ of the Colt's Patent Fire Arms Manufacturing Company, Hartford, Conn., in the capacity of engineer in the machine-gun department.

SIDNEY C. SINGER, formerly superintendent of distribution, Syracuse Lighting Company, Syracuse, N. Y., has become associated with the Omaha Gas Company, Omaha, Neb.

IRWIN H. BENNY has resigned his position as superintendent with the A. H. Fox Gun Company, of Philadelphia, Pa., to accept a similar position with the Westinghouse Electric and Manufacturing Company, Lester, Pa.

PALMER ST. CLAIR, formerly affiliated with the E. I. du Pont de Nemours and Company, City Point, Va., in the capacity of experimental engineer, has become identified with the Air Nitrates Corporation, of New York.

PHILIP M. GUBA has resigned his position with the Jones and Laughlin Steel Company, Pittsburgh, Pa., to accept the position of New York sales manager for the Donner Steel Company.

GEORGE E. HAGEMANN, until recently instructor of mechanical engineering, University of Pennsylvania, Philadelphia, Pa., has become affiliated with the Warren Foundry and Machine Company, Phillipsburg, N. J., in the capacity of draftsman and engineer.

ROBERT H. WALLACE has become associated with the Savage Arms Corporation, Utica, N. Y. He was formerly connected with the Alignum Products Company, South River, N. J., in the capacity of factory manager.

S. R. HUNTER has resigned as superintendent of the gas-engine department of the Fairbanks Morse Manufacturing Company, Beloit, Wis., to become associated with the American Rolling Mill Company, Middletown, Ohio, as supervisor of production.

ANNOUNCEMENTS

D. W. BRUNTON, of Denver, Colo., has been elected a member of the U. S. Naval Consulting Board.

MAJOR E. S. LEA, Ordnance Reserve Corps, has been relieved from duty at his own request, after having served for the last year as chief inspection officer of artillery ammunition, at the Frankford Arsenal, and will resume practice as a consulting engineer, specializing on artillery-ammunition inspection and production.

HAROLD B. VIEDT has resigned his position as assistant superintendent of the radium extraction plant of the Radium Luminous Materials Corporation, Orange, N. J., and has entered the Officers' Training School for Steam Engineers, in the Naval Auxiliary Reserve, and is at present stationed at Pelham, N. Y.

WALTER V. TURNER, manager of engineering of the Westinghouse Air Brake Company, Wilmerding, Pa., has had the degree of Doctor of Engineering conferred upon him by the University of Pittsburgh, at their annual commencement, in recognition of his valuable services to the engineering profession and to humanity.

GEORGE M. BRILL has recently resigned his commission as Major in the Ordnance Reserve Corps to take up the general matter of Requirements for the Emergency Fleet Corporation. He will continue to be located in Washington, since his duties necessitate the maintenance of a number of points of contact with other war activities, such as army, navy, railroad administration, allied purchasing, etc., in the joint study of all requirements for the purpose of avoiding interference and maintaining equilibrium between Supply and Demand.

LOUIS A. DE CAZENOVE has assumed the duties of chief engineer of the National Tractor Company, and supervising engineer of the French American Constructive Company.

GEORGE F. PETTINOS has severed his connections with the firm of Pettinos Brothers, Philadelphia, Pa., which he established in 1892, and is now in busines for himself, following the same lines of business, namely, foundry supplies, iron and steel, molding sands and gravel, and graphite, both foreign and domestic.

HARRY C. WOOTTON has become associated with the Nordyke and Marmon Company, of Indianapolis, Ind.

Walter F. Wells, vice-president and general manager of the Edison Electric Illuminating Company of Brooklyn, has been elected president of the National Electric Light Association.

Tufts College has conferred the honorary degree of Doctor of Science upon Major Ralph D. Mershon, a member of the Naval Consulting Board and formerly assistant professor at Ohio State University.

Arthur B. Babbitt, who for the past six years has been head of the Department of Drawing and Design at Wentworth Institute, Boston, Mass., has resigned that position to become general manager of the Kent Machine Company, Kent, Ohio.

E. O. Estwing has resigned the position of management engineer with the Remington Typewriter Company, for a position as production manager with the Free Sewing Machine Company, Rockford, Ill.

Milton F. Flewelling, Jr., has resigned as chief draftsman of the Ashton Valve Company, Boston, Mass., and has enlisted in the United States Navy.

APPOINTMENTS

O. R. Randolph has been appointed engineer inspector for the State Corporation Commission of Virginia.

Harry Himelblau has been appointed representative of the Baltimore territory for the American Steam Conveyor Corporation.

E. Logan Hill, of New York, has been appointed secretary of the United States Shipping Board Commission on Port and Harbor Facilities. Mr. Hill was formerly assistant to the general manager of the Erie Railroad and affiliated lines, and was granted leave of absence from June 10 to serve on the above commission, which was appointed for the purpose of improving port and terminal facilities to the end that ships may be unloaded, repaired, bunkered and reloaded with the minimum loss of movement and time.

Prof. D. S. Kimball, of Cornell University, has been appointed acting president of Cornell University during the absence of President Schurman, who will shortly sail for France, where he will address the soldiers in the camps.

NECROLOGY

CAPTAIN OSCAR JOHN MAY

Oscar John May, Captain in the Signal Corps, United States Army, died on May 22, 1918, at the Washington Sanitarium, Takoma Park, Washington, D. C.

Captain May was born on May 15, 1878, in Chicago, Ill., and was educated in that city and graduated from the Lewis Institute. From 1900 to 1911 he worked with E. B. Ellicott, electrical engineer for the Sanitary District of Chicago, in various capacities—as operating engineer, constructing engineer and as superintendent of the Sanitary District Power House, Lockport, Ill. As superintendent he installed two of the 6000-hp. hydraulic turbines and generators with the necessary electrical equipment, having under his direction a large force of lubrication engineers for the development of advanced lubrication practice. He was next associated with the Texas Company, first as operating and testing engineer, and later as chief engineer of the Chicago district, supervising practical testing and research work on lubricants. In 1914 he was made assistant superintendent of the company and given charge of the designing and rearranging of mechanical conditions directly affected by lubrication.

Captain May entered the Service in June 1917 as a captain in the Engineers' Reserve Corps, and was recommissioned as a Captain in the Signal Corps in November 1917 and was assigned to the Lubrication Department. He had full charge of the experimental work necessary in the preparation of specifications covering lubricating oil for aeronautic engines, necessitating very elaborate tests at the Washington Navy Yard, where he had under his direction a corps of army and navy engineers. Very important work was also carried on under his personal supervision at the altitude testing laboratory of the Bureau of Standards, where in the first consecutive tests made Captain May stood continuously a watch of sixty-five hours, indicating his remarkable physical endurance and the tremendous interest and conscientious responsibility he felt in the work. He had full charge of the lubrication engineers and oil-house men recently established in the various aviation fields in this country, and also of the special experimental testing work in connection with lubricants and fuel at Dayton, Ohio, and at the various manufacturing plants.

As an indication of the appreciation of Captain May's ability and service he was recommended by the Chief of the Lubrication Department early in February for promotion to the rank of Major.

He was a member of the National Association of Stationary Engineers. He became a member of our Society in 1914.

MATTHEW ANDEN SYKES

Matthew A. Sykes was born on March 26, 1865, in Wallingford, Pa. His early education he obtained in the schools of Delaware County, Pa.; later he took several courses in the evening schools of Philadelphia. He was graduated from The Franklin Institute, his course there being in mechanical drawing.

Fom 1880 to 1890 Mr. Sykes worked with the Baldwin Locomotive Works, Philadelphia, where he first served his apprenticeship and was advanced to the position of contractor and then of foreman on production. For a short period in 1890 he was connected with the Midvale Steel Co., Philadelphia, as foreman in charge of the production work. He left this firm to take a position with Goodell & Waters Co., manufacturers of woodworking machinery in Philadelphia, where he directed the designing and making of tools and planned the work throughout the shop. In 1892 he became foreman with Bement, Miles Co., Philadelphia, and directed the building of special machinery. His next position was with the Sprague Electric Elevator Co., New York, as superintendent of their New York and Watsessing, N. J., plants and of construction on the installation of electric elevators. In 1896 he became superintendent of construction in the New York office of Morse, Williams & Co., Philadelphia, and installed all kinds of hydraulic, electric and belt-power elevators in the metropolitan district. The year 1897 to 1898 he spent with the Metropolitan Electrical Construction Co., on the installation of electric elevators in New York City. In 1898 he became associated with the Otis Elevator Co., New York, as assistant superintendent of construction, installing hydraulic and electric elevators, and for six months was superintendent of construction at the Pittsburgh office of the company. Mr. Sykes left the Otis Elevator Co. in 1905 to become superintendent of construction with the Standard Plunger Elevator Co., Worcester, Mass., of their New York and Toronto offices on the installation of plunger and electric elevators. After six years with this company he was for two years superintendent of construction of the Gurney Elevator Co., and for about a year with the Westinghouse Co., Schenectady, N. Y., as superintendent of their plant manufacturing agricultural machinery, grain separators, steam tractors, locomotive stokers, etc. In 1915 Mr. Sykes accepted a position with the Remington Arms Co., Eddystone, Pa., as superintendent of the division on production work of British rifles. At the time of his death he was superintendent of the erection shop of the Baldwin Locomotive Works, Eddystone, Pa.

Mr. Sykes became a member of the Society in 1917. He died on March 10, 1918.

GOLDWIN STARRETT

Goldwin Starrett was born on September 29, 1874, in Lawrence, Kan. He was graduated from the University of Michigan in 1894 with the degree of B. S. in mechanical engineering and spent the following four years in the office of D. H. Burnham, Chicago, Ill., architect, as architectural draftsman and assistant mechanical engineer. In 1898 he became superintendent and assistant manager in the New York office of the George A. Fuller Co., where he remained for about two years, leaving to take the position of secretary and assistant general manager of the Thompson-Starrett Co., New York. While with this firm he did a vast amount of mechanical work in the construction of commercial and office buildings. In 1904 Mr. Starrett became vice-president of the E. B. Ellis Granite Co., Northfield, Vt., which position he occupied for four years when he became the senior member of the architecural firm of Starrett & Van Vleck, designers of many large and important buildings in New York.

Mr. Starrett was a member of the American Institute of Architects and also of the Architectural League. He became a member of the Society in 1914. He died on May 9, 1918.

CANDIDATES FOR MEMBERSHIP

TO BE VOTED ON AFTER AUG. 10

BELOW is the list of candidates who have filed applications since the date of the last issue of THE JOURNAL. These are classified according to the grades for which their ages qualify them, and not with regard to professional qualifications, i.e., the ages of those under the first heading place them under either Member, Associate or Associate-Member, those in the next class under Associate or Associate-Member, those in the third class under Associate-Member or Junior, and those in the fourth under Junior grade only. Applications for change of grading are also posted. Total number of new applications, 82.

The Membership Committee, and in turn the Council, urge the members to scrutinize this list with care and advise the Secretary promptly of any objections to the candidates posted. All correspondence in this regard is strictly confidential. Unless objection is made to any of the candidates by Aug. 10, and provided satisfactory replies have been received from the required number of references, they will be balloted upon by the Council. Those elected will be notified about Aug. 15.

NOTE. The Council desires to impress upon applicants for membership that under the present national conditions the procedure of election of members may be slower than under normal conditions.

NEW APPLICATIONS

FOR CONSIDERATION AS MEMBER, ASSOCIATE OR ASSOCIATE-MEMBER

Alabama

NAGEL, THEODORE, Resident Engineer, Chemical Construction Co., Sheffield

Colorado

KNOWLES, RALPH R., Superintendent, Construction and Operation, The Ouray Consolidated & Reduction Co., Ouray

Connecticut

HALPIN, JAMES F., Superintendent, Tube and Rod Mills, Bridgeport Brass Co., Bridgeport

Illinois

GOTTSCHAU, CHRISTIAN M., Chief Designer, The Service Machine Corporation, Chicago

THALEG, OSCAR E., District Sales Manager, P. & M. Dept., Worthington Pump & Mchy. Corp., Chicago

PLAGWIT, ERIC, Treasurer and Secretary, The Heine Chimney Co., Chicago

WILLARD, DONALD E., Vice-President and Secretary, Decatur Malleable Iron Co., Decatur

Indiana

CLINE, BENJAMIN J., General Superintendent, Aeroplane Eng. Division, Nordyke & Marmon Co., Indianapolis

Maryland

DEDMAN, BRYANT, Engineer, Poole Engineering & Machine Co., Baltimore

Massachusetts

DOOLITTLE, FRED E., Superintendent, Knox Motors Company, Springfield

KIRMES, EDWIN W., Engineer with Walworth English Flett Co., Boston

LIVERMORE, JOSEPH P., Giving advice and testifying as mechanical expert in patent litigation, Boston

OSGOOD, HARRY E., Sales Engineer, Sanford Riley Stoker Co., Worcester

PICKELS, ROBERT F., Proprietor, Watts Regulator Co., Lawrence

PRARAY, CHARLES W., Mill Engineer and Architect, New Bedford

SAWTELL, WILLIAM H., Superintendent, Worcester Shock Absorber Co., Worcester

STETSON, GEORGE W., Sales Agent, Power Plant Equipment, Boston

WAITE, LORENZO E., General Superintendent of Becker Milling Mch. Co., Boston

WICKSTROM, HANS, Grinding Machinery Salesman, Norton Grinding Co., Worcester

Missouri

KEY, FRED, Vice-President and General Manager, Key Boiler Equipment Co., St. Louis

SOLOMON, CHARLES R., Chief Draftsman and Designer, United Iron Works Co., Kansas City

WISELOGEL, ROBERT F., Second Vice-President, John Nooter Boiler Works Co., St. Louis

New Hampshire

DOWNTON, CHARLES E., Employment Manager, The Atlantic Corporation, Portsmouth

New Jersey

FINKEN, WALTER S., Resident Engineer, Baker, Smith & Co., Morgan

MacARTHUR, DONALD, Manager, Seaboard By-Product Coke Co., Jersey City

SNEDIKER, WALTER J. E., Manager, Ringwalt Linoleum Works, New Brunswick

TAYLOR, KNOX, President, Taylor-Wharton Iron & Steel Co., High Bridge

TRACY, HOMER D., Engineer, Robins Conveying Belt Co., River Edge

New York

CLARKE, VINCENT A., Special Engineer, Niles-Bement-Pond Co., New York

COTTON, HOWARD W., President, H. W. Cotton, Inc., New York

COZENS, ALFRED E., Outside Chief Engineer, Standard Shipbuilding Corp., Shooters Island

FREELAND, WILLARD E., Associate Editor, "The Iron Age," New York

GOBIN, ANDRÉ F., Mechanical Draftsman, U.S. Navy Yard, New York

HATCH, MELLEN C., Assistant to President, Locomotive Pulverized Fuel Co., New York

McCLELLAN, GEORGE F., Inspecting Engineer of public utility properties, Henry L. Doherty & Co., New York

MINER, ROBERT I., Assistant to General Superintendent, The Bossert Corp., Utica

PATTERSON, DUNCAN, Vice-President, Foamite Fire Extinguisher Co., New York

ROBERTS, WILLIAM E., Checker, Wilputte Coke Oven Corp., New York

RODEMEYER, HENRY, Superintendent, Cook Spring Co., New York

TROXELL, EDGAR R., Jr., New York Sales Manager, Spencer Heater Co., New York

VAN FLEET, HERMAN, Engineer in charge, Liquid Air Division, Air Nitrates Corp., New York

North Carolina

WHITE, GILBERT C., Consulting Engineer, Gilbert C. White, Durham

Ohio

SKINNER, ORAMEL H., Engineering Executive, Airplane Engineering Dept., Bureau of Aircraft Production, McCook Field, Dayton

Pennsylvania

BACH, GEORGE W., General Manager, Union Iron Works, Erie

BRAMWELL, JOSEPH W., Manager, Boston Office of American Bronze Corporation, Berwyn

McGINN, Michael J., Superintendent, American Insulation Co., Philadelphia

Washington

ABELL, ASHEL C., Assistant Professor of Mechanical Engineering, Washington State College, Pullman

Cuba

DALE, WILLIAM J., Chief Engineer in charge of Power Installations, Minas de Mathahambre, Pinar del Rio

Holland

VAN DIJK, JAN WILLEM, Dr., Managing Director of J. W. Brouwersplein 2, Amsterdam

India

AVEY, HARRY T., Professor, Ewing Christian College, Allahabad

Italy

DE LACOURT, ALBERTO F., Engineer, Conseil de la Societé Ansaldo, Genoa

FOR CONSIDERATION AS ASSOCIATE OR ASSOCIATE-MEMBER

Connecticut

SCHLEITER, NORMAN H., Secretary, Superintendent and General Manager, Meriden Press & Drop Co., Meriden

New York

SMITH, WILLIAM H. C., Sugar Machinery Engineer, Buyer, W. R. Grace & Co., New York

Pennsylvania

BARKLEY, JOHN F., Assistant Efficiency Engineer, Carnegie Steel Co., E. T. Works, Braddock

EBY, SAMUEL E., Master Mechanic, American Steel Films, care of Thurlow Works, Chester

HEIMPEL, EARL F., Assistant M. M. of Rolling Mill, Bethlehem Steel Corp., Bethlehem

FOR CONSIDERATION AS ASSOCIATE-MEMBER OR JUNIOR

California

KITSON, FRANK C., Junior Engineer with the U.S. Shipping Board, Emergency Fleet Corporation, San Francisco

Connecticut
GLEDHILL, THOMAS, Foreman Dept., M.E.T.L., Remington Arms U.M.C. Co., Inc., Bridgeport

Illinois
NEWTON, LEONARD V., Supervision of Equipment, The Texas Co., Chicago
MADISON, RICHARD D., Chief Draftsman, Indianapolis Office, Ordnance Engineering Bureau, Indianapolis

Maryland
BUSTOS, ENRIQUE, Assistant Engineer, Mechanical Engineer, Baltimore Copper Works, Baltimore

Massachusetts
ARMOUR, WILLIAM W., Vice-President and Superintendent of Armour's Pattern Shop Co., Worcester
STEVENS, HAROLD F., School Teacher, Junior Master, Hyde Park High School, Hyde Park

New York
BEWLEY, WILLIAM E., Manager, Inter-Continental Machinery Corporation, New York
CALDWELL, WILLIAM E., Chemist, The United Electric Light & Power Co., New York
FELLOWS, OLIN B., Vice-President, Ideal Wrapping Machine Co., Middletown

Pennsylvania
PRUDDEN, THEODORE M., First Lieutenant, Ordnance Department, R.C., Frankford Arsenal, Philadelphia
SLEEMAN, EARL C., Chief Draftsman, Monessen Plant, Pittsburgh Steel Products Co., Monessen

Wisconsin
KNOCKE, LOUIS T., Testing Engineer, Waukesha Motor Co., Waukesha

FOR CONSIDERATION AS JUNIOR

Alabama
HARTLEY, ALBERT O., Special Engineering work for Capt. C. G. Landes, U.S. Nitrate Plant, No. 1, Sheffield

Colorado
JOHNSON, EDWIN C., Student graduate, Colorado Agricultural College, Denver

Connecticut
BISHOP, WILLIAM R., Junior Engineer, Gage Dept., Remington Arms,
McKEON, E. JAMES, Designing Draftsman, Remington Arms Co., Bridgeport
MOORE, HENRY H., Tool designer, Liberty Ordnance Co., Bridgeport

District of Columbia
EICHLER, EDWARD, Aeronautical Designer, Bureau of Construction & Repair, Navy Dept., Washington

Illinois
VONACHEN, FRANK J., 2d Lieutenant, Ordnance Dept., N.A., Rock Island Arsenal, Rock Island

New York
BAKER, ROLAND H., Ensign, U.S.N.R.F., U.S.S. Mt. Vernon, New York
MERCNER, RAYMOND O., Designing (Research Design), Western Electric Co., Inc., New York

Ohio
KNOX, CARLOS C., Assistant Inspector of Engineering Material, U.S.N., Cleveland
SNYDER, HOMER R., Foreman at The Hess-Snyder Co., Massillon

Pennsylvania
MARQUARDT, WILLIAM C., Assistant Superintendent, Nelson Valve Co., Philadelphia
UHLENHAUT, FRITZ, III, With Duquesne Light Co., Pittsburgh

Texas
ELSEY, GEORGE W., 2d Lieutenant, R.M.A., A.S.S.R.C., Camp Dick, Dallas

APPLICATIONS FOR CHANGE OF GRADING

PROMOTION FROM JUNIOR

Colorado
KRAEMER, MILTON, Consulting Engineer and General Manager, Standard Potash Co., Senior Member of Firm Kraemer & Schwarz (Reinstatement), Denver

Georgia
GREEN, JOHN S., Superintendent, Southern Iron & Equipment Co. (Reinstatement), Atlanta

Massachusetts
GIFFORD, GEORGE N., Assistant Plant Engineer, American Printing Co., Fall River
PEPPER, CHESTER L., Agent in charge of Industrial Education, Mass. Board of Education, Boston

New York
MONTAGUE, CHARLES E., Mechanical Engineer, The Engelberg Huller Co., Syracuse
ROBBINS, WALTER C., Motor Engineer, Curtiss Aeroplane & Motor Corp., Buffalo

Canada
CARISS, CARINGTON C., Superintendent, 4.5-in. Shell Dept., Waterous Engrg. Wks. Co., Ltd., Brantford, Ontario

PROMOTION FROM ASSOCIATE-MEMBER

Minnesota
BJORGE, OSCAR B., Chief Engineer, Clyde Iron Works, Duluth

New York
STAEGE, STEPHEN A., Consulting Hydraulic and Electrical Engineer, Light & Power Building, Watertown

SUMMARY

New applications	82
Applications for change of grading	—
Promotion from Associate-Member	2
Promotion from Junior	7
Total	91

EMPLOYMENT BULLETIN

THE SECRETARY considers it a special obligation and pleasant duty to make the office of the Society the medium for assisting members to secure positions, by putting them in touch with special opportunities for which their training and experience qualify them, and for helping any one desiring engineering services. The Society acts only as a clearing house in these matters.

GOVERNMENT POSITIONS

Stamps should be inclosed for transmittal of applications to advertisers; non-members should accompany applications with a letter of reference or introduction from a member; such reference letter will be filed with the Society records.

Members applying in person for Government positions at such places as Navy Yards should invariably make appointments beforehand by letter, telephone or telegraph, and arrange to have passes or the equivalents so that they can gain entrance. In this way they will avoid disappointment.

TECHNICAL WRITERS to visit colleges and technical schools and write up courses to be used by the Government in the training of about 90,000 men during the coming summer months. 2620.

HIGH-GRADE EXECUTIVE for ship-construction plant in the South; capable of assuming responsibility for oversight of new construction both for wood and cement ships and supervision of the operation of the property under the direction of a president or general manager. Company is prepared to pay generous salary to right man and will consider giving him an interest in the property if he demonstrates his ability. 2621-A.

ASSISTANT to the above executive. 2621-B.

STATISTICIAN for Fuel Administration to keep records of events in Washington, to design and organize the Statistics Department for his work, to keep records of State operations and present these facts graphically. Location, Washington. 2622.

FOUR MEN FOR FUEL ADMINISTRATION; technical education not essential; of pronounced executive ability to take charge of a group of five States and report their affairs to Washington. 2623.

SUBMARINE FORCE, U. S. NAVY. It is desired to call the attention of young men who have had technical training and experience to the fact that their abilities can best be put at the service of the country by selecting a branch of service in which their special qualifications will be of the greatest use.

The Submarine Force of the United States Navy requires the services, as officers on board submarines, of young men who have had technical training in mechanical and electrical engineering and who have had experience in these professions. It is intended to enroll a number of such men as provisional ensigns in the Naval Reserve Force, give them a course of instruction in deck duties at Annapolis and a course in submarine work at New London. Those who successfully pass these courses will then be sent on board submarines for regular duty.

It is requested that any men who desire this duty and who are qualified as below outlined send their names and addresses to

the Commander Submarine Force, U. S. S. *Chicago*, care of Postmaster, New York.

Qualifications required: Desire to serve in Submarines; degree of M.E., E.E., or E.M.; two and a half years of practical experience in profession; not over 35 years old; physically strong and sound.

Candidates should, if practicable, receive the indorsement of one of the following organizations: Naval Consulting Board; National Research Council; American Society of Mechanical Engineers; American Institute of Electrical Engineers; American Institute of Mining Engineers.

CONANT TAYLOR,
Lieutenant-Commander, U. S. Navy,
Senior Member.

By direction Commander Submarine Force, U. S. Atlantic Fleet. 2624.

CIVILIAN POSITIONS

MECHANICAL ENGINEER for large eastern Massachusetts company, as assistant in physical testing laboratory, competent to take entire charge of this work at an early date. Man of good personality and diplomacy, as part of his work will be investigating conditions in outside plants offering recommendations as to the proper adaptation of our product and assisting salesmen with the bigger propositions. Salary commensurate with experience and demonstrated ability. 0358-G.

DRAFTSMEN, general and mechanical with structural experience. Salary, $135. Location, New Jersey. 0359-G.

SALESMAN on sugar machinery. Expert in operation. Location, Tukaman, Argentine, South America. Salary, $5,000. 0360-G.

ONE MECHANICAL AND ONE ELECTRICAL ENGINEER, preferably married men without children, for positions at sulphur refining factories at Marseilles and Cette, France. Men able to transact business in French. No one with German blood or connections need apply. 0361-G.

INSTRUCTOR in mechanical drawing and possibly some mathematics, for a University on Pacific Coast. Work to begin about the first of October. Salary, $1,200. 0362-G.

ASSISTANT TO GENERAL MANAGER. Must have shop and office experience; preference given to applicant experienced in scientific-management methods or in manufacture of paper or its products. State experience, references, age, salary, and when available. Location, New England. 0363-G.

SALES ENGINEERS, men familiar with furnace and boiler operation and refractories to handle high-grade furnace specialties; fine oportunity for right man. Location, Eastern or Middle Pennsylvania, New York State, Connecticut or Indiana. Salary and commission. 0364-G.

INSTRUCTOR IN MECHANICAL ENGINEERING in recently established department of well-known University. College graduate with some experience in machine design or with internal-combustion engines desired. Salary depends on man engaged. Location, Maryland. 0365-G.

DRAFTSMEN to work out surveyor's maps. Location, New Jersey. Salary depends on man. 0366-G.

YOUNG ENGINEERS FOR OFFICE OF CONSULTING ENGINEER in Pittsburgh; office work, operation and investigation of public utilities. Salary $200 to start. 0367-G.

MATERIAL CHECKERS, young men to check up material for shipment and on receipt at plant, follow distribution to proper departments. Location, Alabama. Salary about $125 a month. 0368-G.

DRAFTSMEN, checkers on industrial plant layouts, elevating and conveying machinery, piping, etc. Headquarters, New York. Salary $30 to $40. 0370-G.

INSPECTORS accustomed to receiving engineering material. Salary $125. Headquarters, Plant tt Muscle Shoals, Alabama. 0371-G.

SUPERINTENDENT, man with executive experience capable of handling mechanics. Location, Niagara Falls, N. Y. Salary, $350. 0372-G.

FILE CLERK, to have charge of files, record of blue prints, distribution and filing. Salary $30. Headquarters, New York. 0373-G.

FILE CLERK FOR DRAFTING ROOM RECORDS. Salary $25. Headquarters, New York. 0374-G.

MECHANICAL ENGINEER, technical graduate with chemical laboratory experience, if possible. Salary, $150. Location, New York. 0375-G.

MECHANICAL DRAFTSMAN, preferably one with experience in hydraulic machinery. Salary depends on man. Headquarters, New York. 0376-G.

DRAFTSMEN, experienced in power-house design and equipment, also foundation and structural works. State age, nationality, and salary expected. Location, New York. 0377-G.

TESTERS AND INVESTIGATORS for large New York company. Work on gas-fired boilers, gas engines, gas heaters, etc. Salary, $20 to $25. 0378-G.

INSTRUCTOR in machine design. Opening in Eastern Institution for M. E. graduate with two or three years' experience on machine design. Give full record. 0379-G.

INSPECTOR OF MECHANICAL AND ELECTRICAL EQUIPMENT. Technical graduate preferred. Salary, $110 to $120. 0381-G.

DRAFTSMEN on power-house layout, and piping. Salary depends on man. Location, New York. 0382-G.

TECHNICAL GRADUATE, man over 30 years of age for estimating and engineering work in general sales department of concern manufacturing large power-plant equipment. Salary depends on man. Location, New York City. 0383-G.

DRAFTSMAN on marine-engine work in factory having large Government contract. Permanent employment for right man. One having oil-engine experience preferred. Location, New York State. 0384-G.

DESIGNER, mechanical engineer for work in connection with development of new chemical plant. Knowledge of chemical industry valuable. Location, Philadelphia. 0385-G.

SHIPBUILDING DRAFTSMEN. Salary, $35 to $40. Location, Brooklyn, N. Y. 0386-G.

SALES ENGINEER, 24 to 25 years old, exempt or class 4. Good appearance and personality; energetic and willing to work. Must have initiative and be a thinker. College degree and one year shop work on telephone or electrical equipment; or high school education and two or three years shop work as above. Location, New York to travel. Salary about $1,500 to $1,800. 0389-G.

ENGINEERING EDITOR, with mechanical engineering education, some appreciation of the economic side of engineering and some insight into shop management, a liking for writing; good address, and if possible, so-called mixing qualities. Age preferably between 30 and 40 years. Salary depends on his measuring up to these specifications, his experience, and the time needed to make him a producer. He is wanted for one of the most important positions on Engineering Journal of enviable reputation, and his progress will be dependent solely on his ability to make good. 0390-G.

ESTIMATOR wanted by firm doing high grade of work and which offers possibilities of developing to assistant in charge of the department where all estimating work is done. Requires knowledge of general building construction. Location, New York. 0391-G.

MASTER MECHANIC OR PLANT ENGINEER, technical graduate with engineering ability, who has had practical experience along these lines. Location, New Jersey. Salary, $2,500 to $3,000. 0392-G.

DRAFTSMEN on power plants. Location, New York. Salary, $140. 0394-G.

TOPOGRAPHICAL DRAFTSMAN wanted by New York City firm. 0395-G.

MAINTENANCE ENGINEER to take care of all piping and pipe line in plant. 0396-G.

INSPECTOR PIPE COVERING. Salary about $200. 0397-G.

MASTER MECHANIC, with experience in handling men and in repair maintenance and up-keep of mechanical equipment used in chemical plants. 0399-G.

PRODUCTION ENGINEERS for staff of firm located in New York City. 0401-G.

CHIEF ELECTRICAL ENGINEER, experienced in repair and maintenance of electrical equipment. Salary $3,000 to $3,600. Headquarters, Alabama. 0404-G.

TWO MECHANICAL ENGINEERS, with civil-engineering experience if possible, in maintenance of cement, fertilizing and chemical plants, including roads, sewer, water-gas, steam and air lines all sizes and pressures. 0405-G.

FOUR ASSISTANT MASTER MECHANICS, experienced in repair work, maintenance, operation and equipment, as used in cement, fertilizing and chemical plants. Location, Alabama. 0406-G.

TEN FOREMEN familiar with mechanical piping, electrical work, blacksmithing, welding, structural steel, sheet metal, etc., having experience in charge of shops. 0407-G.

COMBUSTION ENGINEER, man familiar with fuel problems, sampling coal, able to make researches, determinations of product, and to handle sampling force of five men. Salary depends upon man. 0409-G.

FOREMAN for sampling department. 0408-G.

COST CLERK to estimate on costs of equipment, appraisal work, etc. Location, Alabama. Salary, $130 to $160. 0410-G.

OFFICE EXECUTIVE for office-cost department, having charge of crane and other machine costs, preparing these for use of sales department in making their estimates and proposals. Man must be steady, reliable, and preferably married. Good accountant and must possess sufficient executive ability to direct four or five others under him and get out the work assigned to him; will be expected to work himself and get into the details of this department. Location, Michigan. 0411-G.

TURBINE MAINTENANCE ENGINEER, man for inspection of turbine and auxiliary equipment and taking charge of the major repairs to apparatus for large power company operating several stations. One with experience with Westinghouse turbine preferred. Location Pennsylvania. 0413-G.

BOILER MAINTENANCE ENGINEER, man for inspection of boilers and boiler-room apparatus. One with construction experience in large boilers preferred. Location, Pennsylvania. 0413-G.

MASTER MECHANIC for large power plant; experienced in repairs and maintenance of large turbo-generators and boilers. Location, Pennsylvania. 0414-G.

ENGINEER to take charge of large generating station, consisting of three 10-kw. General Electric turbo-generators with 8 Stirling boilers equipped with Coxe traveling stokers for burning small sizes of anthracite fuel. Plant has three shifts of 8 hr. each and employs about 100 men. Man to take charge of this station should have considerable executive ability as well as general operating knowledge. Location Pennsylvania. Salary $3500 to $4000. 0415-G.

SUPERINTENDENT for growing concern having machine shop, foundry, pattern shop and blacksmith shop, just starting on attractive specialty, requiring capable superintendent experienced in above lines, and a good systematizer. Excellent opportunity for a young man. Location Michigan. 0417-G.

ASSISTANT ESTIMATOR, man able to take off accurate quantities for mechanical equipment from engineers' drawings, and have fair idea of cost of various machine-shop operations, pattern making, and the installation of steam lines, shafting and general mill equipment. Position will probably last from 1½ to 2 years with good opening later on for capable man. For first few weeks he would be required to help on the quantities for reinforced-concrete buildings, etc. Location Ontario, Canada. Salary $130 to $150 to start. 0418-G.

FIELD INSPECTORS wanted on electrical, plumbing and drainage work. 0419-G.

ENGINEER-DESIGNER on reinforced concrete, light steel construction. Salary $250 up. 0420-G.

DRAFTSMAN of conveying machinery. Salary depends on man. Location New York. 0421-G.

YOUNG TECHNICAL MEN with a few years of practical experience, preferably along executive lines; men with good common sense and tact. Opportunities are innumerable and a good man has chance to advance rapidly. Location Virginia. Salary $150 to $200. 0422-G.

MARINE DRAFTSMEN in connection with piping layouts and machinery arrangements. Location Pennsylvania. Salary according to qualifications. 0423-G.

LABORATORY ASSISTANT in instrument and standardizing laboratory for men of technical ability to carry out research work. Location Massachusetts. 0424-G.

CONSTRUCTION, ARCHITECTURAL and MECHANICAL DRAFTSMEN wanted for Government work connected with the ship-construction program at Philadelphia. Also SQUAD CHIEFS and SPECIFICATION WRITERS. 0425-G.

TECHNICAL GRADUATE with considerable practical training and experience. Man abreast of the times, with respect to the developments in the design and application of machinery; capable of supervising the design and manufacture of special tools and equipment; up-to-date in modern machine-shop practices and who possesses executive ability of a high order. Age 35 to 38 years. Location New York State. 0428-G.

POWER PLANT ENGINEER, must be familiar with modern boiler-room practice. Location Pennsylvania. 0429-G.

MECHANICAL DRAFTSMEN on Government Shipyard work near Philadelphia.

CONSTRUCTION ARCHITECTURAL DRAFTSMEN on heavy steel and concrete work. State salary expected, age, experience, and when available. 0430-G.

PRODUCTION ENGINEER for concern manufacturing gages, fixtures and cutters to speed up deliveries of shop doing war work. Give past experience and salary expected. 0431-G.

INSTRUCTOR in mechanical engineering, to teach descriptive geometry, machine drawing, some laboratory work, and elementary steam engineering. Salary $1500 per year. Location Ohio. 0433-G.

YOUNG MAN not subject to draft in very near future. Mechanical training not necessary, but must have a fair knowledge of drafting. Immediate chance of advancement. Salary $75 to $100 per month to start. 0436-G.

CIVIL ENGINEER with knowledge of mechanics; good instrument man experienced in the execution of plans, laying out buildings, following out plan work, concrete work, construction, steel work, trestles, etc. Should be able to follow construction of bridges, sewers, roads and mill machinery. Location Canada. 0437-G.

ENGINEER IN CHARGE OF DIVISION OF CONSTRUCTION AND DESIGN for New York office of chemical plant. 0438-G.

ASSISTANT PURCHASING AGENT for chemical plant in New York City. Some travelling. 0439-G.

PRODUCTION MANAGER familiar with, and experienced in factory production. Location Alabama. 0440-G.

EXECUTIVE REPRESENTATIVE. Man to attend to affairs in Washington and report back to head office. 0441-G.

GENERAL CONSTRUCTION ENGINEER AND EXECUTIVE wanted as general assistant to the resident manager. Salary $7500. Location Alabama. 0446-G.

OFFICE MANAGER for resident manager in the field. Salary $3000. Location Alabama. 0447-G.

GENERAL CONSTRUCTION AND EQUIPMENT ENGINEERS on staff of resident manager. Works or equipment engineer, no chemistry necessary. Salary $2400 to $3600. 0448-G.

ASSISTANT SUPERINTENDENT of construction of coal, lime and coke plant. Salary $225. Location Alabama. 0449-G.

ASSISTANT SUPERINTENDENT of construction of carbide and lime-nitrogen plants. Salary $225. Location Alabama. 0450-G.

ASSISTANT SUPERINTENDENT of construction on liquid-air plant. Man familiar with erecting air compressors, high-pressure piping, etc. No technical knowledge of liquid-air works required. Salary $225. Location Alabama. 0451-G.

ASSISTANT SUPERINTENDENT of construction of nitrate plant. Some knowledge of nitrate plants and equipment desirable, but not essential. Salary $225. Location Alabama. 0452-G.

ASSISTANT SUPERINTENDENT of construction of nitric-acid plant. A comprehensive knowledge of nitric-acid work highly desirable, and a fair working acquaintance essential. Salary $225. Location Alabama. 0453-G.

ELECTRICAL AND MECHANICAL ENGINEERS for plant-layout work. Temporary employment. Location New Jersey. 0454-G.

TESTS ENGINEER, man experienced in the operation of boilers, engines, etc. Work covers testing and investigations in steel mills in western Pennsylvania, Ohio, West Virginia, and Indiana. 0455-G.

PRODUCTION ENGINEER for large established New England manufacturer of mechanics' hand tools; high-grade man with executive qualifications. Must be technical graduate with successful factory and labor experience, possess initiative and be familiar with modern methods of producing mechanics' hand tools and kindred products under favorable and profitable conditions, and generally competent to meet with diplomacy all wage and product problems. Man of 35 to 40 years of age preferred. State age, experience, salary expected, and when available. 0456-G.

DRAFTSMAN, 19 to 30 years of age; man who can think as well as work; the more education the better. A few years' training, preferably in shop and drawing room on medium or heavy machinery. No instrument makers or electricians wanted. Location, Newark, N. J. Salary about $100. 0388-G.

DETAIL EQUIPMENT SUPERINTENDENT for carbolite furnaces and electrode shop. Maximum salary $250. 0398-G.

TESTS ENGINEER, 25 to 38 years old, aggressive, analytical mind, worker. Complete technical foundation, college graduate. Must be trained in responsible engineering work, preferably along testing and research lines, either mechanical or electrical. Location Newark, N. J. Salary about $200. 0387-G.

MECHANICAL-LABORATORY ASSISTANTS and DRAFTSMEN required for important war work in development of parts for sheet metal, fabric and rubber. Graduates from manual-training schools with one or two years' shop experience or one or two years in an engineering school. Enclose photograph, state age, give references, position in draft and willingness to enlist or be induced in the army for work of this nature. 0459-G.

MEN AVAILABLE

Only members of the Society are listed in the published notices in this section. Copy for notices should be on hand by the 12th of the month, and the form of notice should be such that the initial words indicate the classification. Notices are not repeated in consecutive issues.

MECHANICAL ENGINEER, age 34, married, college graduate, 15 years' experience, employed but looking for greater possibilities than present position offers. Will be glad to consider one requiring initiative and organization ability along executive lines. Correspondence with firms desiring to be represented in Washington especially invited. G-177.

EXECUTIVE ENGINEER SALES OR DISTRICT MANAGER, Eastern territory preferred account of large acquaintance here, 12 years' experience handling power-plant equipment and power-transmission machinery. Graduate mechanical engineer, can show record as to results and ability to get business; ten years in last position with concern of national reputation. G-178.

MECHANICAL ENGINEER, Member, technical graduate, age 39, desires position as engineer or chief draftsman. Expert in design of high-power hydraulic turbines, governors, etc., also shop practice, layout of power plants and design of general machinery. One year's experience in a testing laboratory for machinery and material. G-179.

ASSISTANT TO PRESIDENT OR GENERAL MANAGER of a manufacturing company desired by a resourceful and successful executive mechanical engineer with broad industrial experience in factory layouts, equipment and management. Complete record on request. G-180.

PRODUCTION OR PRODUCTION EQUIPMENT ENGINEER, mechanical superintendent or assistant or other responsible position on either designing or manufacturing end or both. Must be war work. Salary about $4000. Would like to correspond with party needing self-starting man for above positions. Have successfully held them and am also practical mechanic and designer. Experience covers originating, designing, building and operating numerous special and standard automatic and semi-automatic machines for producing a wide variety of articles from wire, sheet metals, paper, wood, etc., for assembling, labor saving, processing, conveying, cost reducing, etc. Punches and dies, jigs, fixtures and tools and general engineering. Also routing cost accounting, bookkeeping, time study and production. Will finish contract on non-essential work and be available shortly. Prefer place where the position is big and difficult and with after-the-war prospects. Am an American, 28 years old, married with family, draft exempted. Will go anywhere. G-181.

EXECUTIVE, ENGINEER; American; 35 years of age; married; University graduate; general engineering experience; four years electrical and mechanical consulting office, one year construction draftsman, four years chief designing engineer for large public utility holding corporation in charge of design, materials and construction. At present employed as assistant works engineer for motor company. Easily adaptable to conditions; energetic and ambitious. Will consider contract with reliable permanent industrial organization. Central location preferred. G-182.

MECHANICAL ENGINEER, Junior Member, age 28, class IV in draft. Technical graduate with training and experience along mechanical and electrical lines in manufacturing and testing work in a large manufacturing plant. Desires position offering good opportunities and preferably located in Chicago or the Middle West. G-183.

A COMPETENT FOUNDRY MAN will be available June 1. Capable of handling any foundry position; has had vast experience in handling complicated foundry work and can give satisfactory reasons for wanting to change position. G-184.

EXPERT INDUSTRIAL EDUCATION AND SAFETY ENGINEER. Graduate Massachusetts Institute of Technology, mechanical engineering, 1911, 29 years of age, married, in Class IV of the draft. Have three and a half years' experience as factory inspector, fire protection and safety engineer. For last four years have had charge of all day and evening industrial education for men and boys in largest manufacturing state in the country. Can furnish highest credentials. Desire position of greater responsibility. Salary $3500 or over. Location in New England preferred. G-185.

ASSOCIATE MEMBER, with 20 years' experience in designing, constructing and operating power plants, sub-stations, pumping plants, factories, gas-producer plants, etc., also extensive experience designing and constructing electric railway and floating equipment, will be open for engagement about June 15. Competent to assume full charge and to produce results. No objections to office or drafting work. G-186.

SALES AGENT, mechanical engineer, technical graduate, 13 years' experience in selling, designing and estimating, desires to represent high-class manufacturer in New England territory with headquarters in Boston. Best of references. G-187.

EXECUTIVE OR PURCHASING ENGINEER in touch with largest manufacturers of mechanical, electrical equipment and sources of engineering materials; presently engaged along these lines. Wishes connection with opportunities for greater activity. G-188.

MECHANICAL ADVISER AND DEVELOPMENT ENGINEER. Special machine designer, policy investigator, practical and technical education, good organizer and systematizer. Specialist on mechanical efficiency operation. Expert on substituting mechanical devices for hand labor. Past 15 years specializing on designing, developing and manufacturing up-to-date cost-cutting appliances, special equipment, tools and labor-saving devices for manufacturing special product efficiently. Age 35. Associate member. Salary $4800. Desire new connections with large corporation contemplating improving or redesigning its present manufacturing methods where above experience is essential. Location vicinity Newark or New York City. G-189.

MECHANICAL, ELECTRICAL ENGINEER. American, 14 years' practical and theoretical experience in manufacture of engineering specialties, machine tools, shop equipment, power, machinery and shop maintenance, oxy-acetylene, drafting, physical and experimental testing, shop welfare and power-house work. An executive with initiative and aggressiveness. At present employed. Location immaterial. Salary $2800 and expenses. G-190.

EXECUTIVE MANAGER, Member, with experience in designing, manufacturing, installing, estimating and selling of electric, pneumatic and mechanical apparatus. Experienced in the investigation of unsatisfactory methods and conditions and capable of devising and executing efficient remedies. New York or vicinity preferred. G-191.

GRADUATE ENGINEER, with ten years' active and consistent experience in the practice of principles of industrial management; is not an efficiency engineer or cost clerk. Will associate himself with a bank as industrial expert or with large manufacturing enterprise as confidential assistant to president or manager, or will take charge of an executive department but not below works manager. Available July 1. G-192.

EXECUTIVE, MECHANICAL, and ELECTRICAL ENGINEER. Strong technical man on power and power equipment. Has had 12 years' operating and construction experience with large public-utility and manufacturing companies. An exceptional man for a manufacturing or operating company. 35 years of age, and married. G-193.

SALES ENGINEER, mechanical engineering graduate, two years' experience, desires to get in touch with manufacturer in Middle West, having opening in office or in outside work. No continuous traveling desired. Experience in air-compressor work and heat-treatment of metals. Salary $200 jer month. G-194.

GENERAL MANAGER. Graduate mechanical engineer, 40 years old member, at present engaged, desires opening as general manager of manufacturing company in which he can obtain an interest. New England preferred. Twenty years' experience in manufacturing heavy and light machinery, selling and management. G-195.

MECHANICAL ENGINEER, now chief engineer of small concern, desires position with medium or large concern as chief draftsman, head of development work, or other executive position. Experience in general engineering, automatic machinery and machine tools, hydraulic machinery, rubber celluloid manufacture, electrical heating for industrial purposes, quantity manufacture, system and organization generally; some airplane experience. New York, Newark and vicinity preferred. Salary not under $3000. G-196.

MEMBER with broad business and engineering experience here and abroad, American, 45; fully conversant with the principal languages; knowledge of purchasing and selling; tactful in handling of men; at present employed as designer of special plant. Desires change by September 1, preferably to supervise work, inspect or represent, or act as assistant to executive where responsibility is required. To start, $4000. G-197.

EXECUTIVE MECHANICAL ENGINEER, member of leading professional societies, important war committees and commissions, degrees, author, American, employed on technical research and development work in non-essentials; special ability, mechanical invention, simplification of design, cheapening and elimination of manufacturing operations, industrial-plant operation, cost reduction, etc.; seeks more war-essential duties. Usefulness first, salary secondary consideration. G-198.

EXECUTIVE OR ASSISTANT. Cornell M. E., with nine years' practical experience in shipyard, machine shop, and general heavy and medium work. Capable of directing work and men with maximum production and minimum friction. Capable and thorough organizer, familiar with manufacturing details. Salary at least $2800. G-199.

ENGINEERING SURVEY

A Review of Engineering Progress and Attainment in Mechanical Engineering and Related Fields, Including a Digest of Current Technical Periodicals and Selected Titles of Engineering Articles

Evolution of the Aircraft Engine

The War Department authorizes the following statement of evolution in aircraft engines prepared by the National Advisory Committee for Aeronautics:

The first man-carrying airplane flights were made in December 1903, with the Wright Bros.' engine, developing 12 hp. and weighing 152 lb., or 12.7 lb. per hp. In 1910, seven years later, the average horsepower of aeronautic engines had increased to 54 and the weight decreased to 5.7 lb. per. hp. In another seven years, 1917, the average power output had advanced to 243 hp. and the weight decreased to 2.8 lb. per hp. In March 1918 the Liberty 12 developed 432 hp. for a weight of 808 lb., or 1.86 lb. per hp. At the present time (May 1918) the Liberty 12 is yielding a maximum of 450 hp. for a weight of 825 lb., or 1.83 lb. per hp.

Advance in Ratio. The accompanying table shows the advance in the average power-weight ratio by years for the engines in actual flying use. It is to be especially noted that the Langley-Manly engine, built in 1901, was 9 years ahead of its time in the matter of power output, and 16 years ahead in its weight per horsepower.

In 1917 the Liberty 12 was 65 per cent more powerful and 28 per cent lighter per horsepower than the average in service for that year. So far this year these figures are probably changed to 50 per cent and 25 per cent, respectively, which indicate the advance of the Liberty over the average engine in service at the present time.

AIRCRAFT-ENGINE EVOLUTION

	Year	Horsepower	Weight, lb.	Weight per horsepower, lb.
Langley-Manly engine	1901	52	151	2.9
Original Wright Bros.	1903	12	152	12.7
Improved Wright Bros.	1904	16	180	11.4
Improved Wright Bros.	1905	19	180	9.5
Redesigned Wright Bros.	1908	35	182	5.5
Average on market	1910	54	309	5.7
Wolseley engine	1913	147	720	4.9
Average on market	1914	112	437	3.9
Average on market	1915	133	512	3.8
Average on market	1916	185	570	3.1
Average on market	1917	243	693	2.8
Liberty 12-cylinder	1917	400	801	2.0
Liberty 12-cylinder (March)	1918	432	808	1.9
Liberty 12-cylinder (May)	1918	450	825	1.8

Consumption of Fuel. The average consumption of fuel decreased from about 0.8 lb. per hp-hr. in 1903 to about 0.65 lb. in 1914, since which it has slowly dropped to 0.55 lb. in 1918, and for the Liberty to 0.50 lb. The present Liberty consumption is approximately 0.46 lb. per hp-hr.

Illustrating the advance made, the Wolseley Co. in 1913 could only obtain 147 hp. at 1400 r.p.m. from eight cylinders, 5 in. bore by 7 in. stroke, or 18.375 hp. per cylinder. This is the same size cylinder as used in the Liberty, which now gives 450 hp., at 1800 revolutions, from 12 cylinders, or 37.5 hp. per cylinder, which is double the power per cylinder obtained in the Wolseley. Even if we reduce the Liberty results to the same speed as the Wolseley—that is, 1400 revolutions—the Liberty still represents a great advance, for at that speed 350 hp. are developed, or 29.2 hp. per cylinder. Moreover, the Wolseley weighed 4.9 lb. per hp. as compared with 2.3 for the Liberty at the same speed, or 1400 r.p.m. (*The Official Bulletin*, June 12, 1918, p. 16.)

International Aircraft Standards

As has been previously stated in The Journal, an American commission has recently been sent to Europe, where it spent several weeks in conference with engineering representatives of the Allies on the formulation of specifications of materials, mounting and dimensions of parts for aircraft and automotive apparatus generally.

The general feeling is that these conferences have constituted a real advance and facilitated ultimate international standardization. A formal international conference was held in London with representatives of France, Italy, Great Britain and the United States being present. A number of less formal sessions and conferences were held in various places, and many factories, repair stations, laboratories, etc., were visited.

The prime objects of the conferences were to facilitate the sending of most usable supplies to England, France and Italy from the United States, and also to arrange so as to have parts, fittings and instruments made interchangeable on aircraft produced in the different countries.

Progress was made at the conference abroad in the formulation of Allied standard specifications for aircraft steels, using the current American, British, French and Italian specifications as a basis, covering both the general procedure for testing and the chemical and physical requirements of wrought steels.

In the metric sizes the S.A.E. and the British ball-bearing series are identical, except that six S.A.E. sizes have not been included in the British list. A revision of tolerances and limits recommended by the British and the American delegates is under consideration. Limits of eccentricity in radial bearings and outside dimensions of thrust bearings were other subjects of study.

The 18-mm. spark plug, incorporating the best features of the British and the S.A.E. plugs, has been recommended for use on American and British stationary-cylinder and rotary engines. Practically the same plugs are used in France and Italy.

The dimension specifications for British and for American magnetos are substantially the same, with the exception of one dimension of magneto space. The American specification of the taper as one in five is the same as the British specification of the taper as one in ten, owing to the fact that the British refer to the slope of the conical surface to the axis.

The plan, provisionally adopted by the subcommittee of the International Commission on Pipe Threads, which met in Paris, July 1914, for a standard method of designating units of construction, was discussed, with reference particularly to screw threads and gear-wheel teeth, the idea being to seek

a unit which could be used when either the inch or the metric system is employed. Taking screw threads as an illustration, a system of notation was outlined by which each screw would bear a distinctive number based on the diameter in eighths of an inch, and the pitch in the number of threads per inch or per 127 mm. (= 5 in.), without reference to the unit in which the measurement might be made. For example, a ¾-in. U. S. standard bolt having 10 threads per inch would be designated a "6 x 50" bolt in countries using the metric system. The selection 127 mm. as the length over which the number of threads should be stated in countries using the metric system is based on the fact that this gives *whole* number of turns, these being five times the number of threads per inch.

The very difficult problem of bringing together the advocates of the metric and of the inch bases is in abeyance, but it is felt by some that the plan outlined above may afford the first step.

The practices in the preparation and use of glue are much the same in the United States and Great Britain. Mechanical methods of application and electrical method of heating are used largely here, but neither of these methods is common in England. Comparative tests of British and American methods of testing glue are being made.

The question of spruce supply was naturally discussed. Kiln procedure has been simplified, the results being satisfactory almost invariably. It is appreciated by all that the splicing of wood is an important subject. Additional approved designs of laminated and box spars will be recommended.

Propeller-hub and fittings practice will be further unified so far as shall prove advisable and possible.

Coördination of water and fuel piping standards is largely dependent on thread practice. The use of outside dimension only for nominal diameters of metal tubing has been recommended by the British and the American committees.

The British and American practice in wheels and tires are substantially in accord. Discussion is being had as to the advisability of extending the list of wheel sizes which has been adopted here.

The number of tire sizes will be kept to the lowest possible minimum.

The British and the American steel wire cables are sufficiently alike to be practically interchangeable. The same thing is true of high-tension steel wire.

It is felt that similarity of design is not necessary in turnbuckles, satisfactory interchangeability being securable if the fork-end and pin dimensions are standardized.

The single aim in considering the various matters is to ascertain to what extent we can, without interfering with our productive capacity, adopt European standards with advantage; to what extent we can assist more effectively in cases of European conformity with our practices; following the course that will bring the best results. That which does not contribute to the winning of the war is of quite secondary importance. Anything that does contribute to the winning of the war is obviously of prime importance. (Abstract of a paper presented by Coker F. Clarkson before the *Society of Automotive Engineers*).

Standard Heavy-Duty Motor Truck Adopted by War Department

The following statement is authorized by the War Department:

One of the questions of standardization of motor transportation for use of the Army has been settled by the Secretary of War, i.e., the quartermaster standard type B truck has been officially adopted as the standard heavy-duty cargo truck for use of the Army in all its departments requiring this capacity truck. A large number of these trucks are now on order, and it is expected that the first 10,000 of these will be completed on or about August 1, 1918. (*Official Bulletin*, June 7, 1918, p. 8)

The Liberty Engine Described in Detail

The War Department authorizes the following statement:

The designs of the parts of the Liberty engine were based on the following:

Cylinders. The designers of the cylinders for the Liberty engine followed the practice used in the German Mercedes, English Rolls-Royce, French Lorraine-Dietrich, and Italian Isotta Fraschini before the war and during the war. The cylinders are made of steel inner shells surrounded by pressed-steel water jackets. The Packard Company by long experiment had developed a method of applying these steel water jackets.

The valve cages are drop forgings welded into the cylinder head. The principal departure from European practice is in the location of the holding-down flange, which is several inches above the mouth of the cylinder, and the unique method of manufacture evolved by the Ford Company. The output is now approximately 1,700 cylinder forgings per day.

Camshaft and Valve Mechanism Above Cylinder Heads. The design of the above is based on the Mercedes, but was improved for automatic lubrication without wasting oil by the Packard Motor Car Company.

Camshaft Drive. The camshaft drive was copied almost entirely from the Hall-Scott motor; in fact, several of the gears used in the first sample engines were supplied by the Hall-Scott Motor Car Company. This type of drive is used by Mercedes, Hispano-Suiza, and others.

Angle Between Cylinders. In the Liberty the included angle between the cylinders is 45 deg.; in all other existing 12-cylinder engines it is 60 deg. This feature is new with the Liberty engine, and was adopted for the purpose of bringing each row of cylinders nearer the vertical and closer together, so as to save width and head resistance. By the narrow angle greater strength is given to the crankcase and vibration is reduced.

Electric Generator and Ignition. A Delco ignition system is used. It was especially designed for the Liberty engine to save weight and to meet the special conditions due to firing 12 cylinders with an included angle of 45 deg.

Pistons. The pistons of the Liberty engine are of Hall-Scott design.

Connecting Rods. Forked or straddle-type connecting rods, first used on the French DeDion car and the Cadillac motor car in this country, are used.

Crankshaft. Crankshaft design followed the standard 12-cylinder practice, except as to oiling. Crankcase follows standard practice. The 45-deg. angle and the flange location on the cylinders made possible a very strong box section.

Lubrication. The first system of lubrication followed the German practice of using one pump to keep the crankcase empty, delivering into an outside reservoir, and another pump to force oil under pressure to the main crankshaft bearings. This lubrication system also followed the German practice in allowing the overflow in the main bearings to travel out the face of the crank cheeks to a scupper which collected this excess for crankpin lubrication. This is very economical in the use of oil and is still the German standard practice.

The present system is similar to the first practice, except that the oil, while under pressure, is not only fed to main bearings but through holes inside the crank cheeks to crankpins, instead of feeding these crankpins through scuppers. The difference between the two oiling systems consists of carrying oil for the crankpins through a hole inside the crank cheek instead of up the outside face of the crank cheek.

Propeller Hub. The Hall-Scott propeller-hub design was adapted to the power of the Liberty engine.

Water Pump. The Packard type of water pump was adapted to the Liberty.

Carburetor. A carburetor was developed by the Zenith Company for the Liberty engine.

Bore and Stroke. The bore and stroke of the Liberty engine is 5 by 7 in., the same as the Hall-Scott A-5 and A-7 engines, and as in the Hall-Scott 12-cylinder engine.

Remarks. The idea of developing Liberty engines of 4, 6, 8 and 12 cylinders with the above characteristics was first thought of about May 25, 1917. The idea was developed in conference with representatives of the British and French missions, May 28 to June 1, and was submitted in the form of sketches at a joint meeting of the Aircraft (Production) Board and the Joint Army and Navy Technical Board, June 4. The first sample was an 8-cylinder model, delivered to the Bureau of Standards, July 3, 1917. The 8-cylinder model, however, was never put into production, as advices from France indicated that demands for increased power should make the 8-cylinder model obsolete before it could be produced.

Work was then concentrated on the 12-cylinder engine, and one of the experimental engines passed the 50-hour test August 25, 1917.

After the preliminary drawings were made, engineers from the leading engine builders were brought to the Bureau of Standards, where they inspected the new designs and made suggestions, most of which were incorporated in the final design. At the same time expert production men were making suggestions that would facilitate production.

The Liberty 12-cylinder engine passed the 50-hour test, showing, as the official report of August 25, 1917, records, "that the fundamental construction is such that very satisfactory service with a long life and high order of efficiency will be given by this power plant, and that the design has passed from the experimental stage into the field of proven engines."

An engine committee was organized informally, consisting of engineers and production managers of the Packard, Ford, Cadillac, Lincoln, Marmon and Trego companies. This committee met at frequent intervals, and it is to this group of men that the final development of the Liberty engine is largely due. (*Official Bulletin*, May 16, 1918, p. 3)

New German Textile Substitute

There has been much discussion in the German press recently concerning a wood-pulp fiber named "cellulon," for which large claims are made as an efficient substitute for jute, cotton and other fibers. The Swiss spinners and weavers are keenly watching the developments of this textile substitute and already regard it as of considerable importance. A memorandum on the subject has been received by the Foreign Office from the British Consul General at Zurich, who has seen a sample of the cloth made from cellulon, and describes it as extremely strong, although made directly from wood pulp.

It is not easy to reconcile the various descriptions of the process of manufacturing cellulon from pulp, and it may be that more than one method is employed. It appears to be certain that the fiber is not made by spinning long strips of paper run off reels through water in the manner which German paper textile substitutes have made familiar. The accounts agree in describing the process, or processes, as a direct manufacture from wood pulp.

The British Consul General states that the method employed is on the same general principles as artificial-silk manufacture—that is, by squeezing pulp under high pressure through small holes in plates. He is familiar with the artificial-silk works at Crefeld and considers that the methods employed there are adaptable to making cellulon.

On the other hand, the *Münchener Neueste Nachrichten* gives some details of two processes: one, the invention of an engineer named Scherback, and the other the revival of the discovery made 25 years ago by Gustav Turk. In the Turk process, according to the Munich journal, the cellulose pulp is conducted over drums, the surface of which is divided into parallels corresponding to the number of the yarns to be produced. The roving, which consists of a solid mass of cellulose, is taken from the drum by means of a special apparatus and then twisted (i.e. finished or twined) on spinning machines.

In the Scherback process cellulose is added to cotton waste or wool in the ordinary mixed spinning process. The somewhat longer fibers of the cotton or wool bind together the shorter cellulose fibers, and thus a yarn is produced similar to cotton or woolen yarn. These processes materially differ from one another, and from the method of manufacture—similar to that of artificial silk—which is described by the Consul General at Zurich. They agree, however, in one respect: that cellulon is made from wood pulp which has not been previously converted into paper.

But however cellulon may be manufactured, there is no doubt that it is being exploited very actively in Germany, especially as a substitute for jute. The *Münchener Neueste Nachrichten,* which describes the extent of its adoption in Germany up to last month, states that many of the largest industrial concerns in the cellulose, paper and textile industries have already taken out licenses for the working of this invention. Some large factories are already at work exploiting it; other factories for such exploitation are being built or projected. The Cellulon Company has been formed by the existing license holders in conjunction with the proprietors of the patent (namely, The Turk Company, Ltd., Hamburg), with the object of establishing a research company, as well as a central point for all common interests of the cellulon industry.

The British Consul General writes that the Augsburger Spinnerei A. G. is largely interested in the Cellulon Company, and that a very powerful combination of spinners and weavers has been formed. (*Journal of Commerce,* May 31, 1918, p. 3)

Three Training Camps Open with 6,500 College Students

The following statement is authorized by the War Department:

Reports received in the Adjutant General's office indicate that the three training camps for college students opened with the full quotas present. The camps are located at Plattsburg, N. Y., where 3,000 students are enrolled; Fort Sheridan, Ill., where there are 2,500 students, and the Presidio, San Francisco, where there are 1,000. All three camps opened on Monday for a one-month course of training.

Only infantry instruction is given at these camps. Full equipment of the latest model has been furnished. The object of the camps is to prepare students with such additional training as may be prescribed for commissions in the Officers' Reserve Corps.

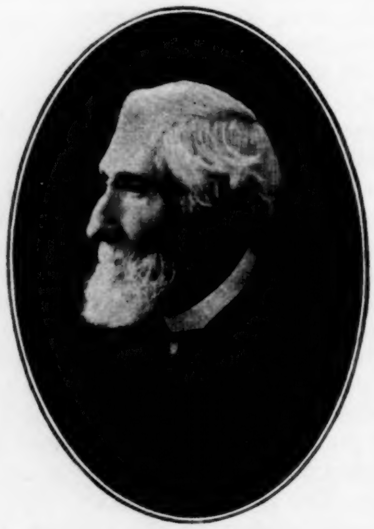
Those who qualified for the camps are members of Reserve Officers' Training Corps units which are located at about 120 different colleges and universities. Members of the camps receive mileage and subsistence. Most of them are under military age.

A similar camp for college students who are members of artillery units of the Reserve Officers' Training Corps at Yale University and the Virginia Military Institute, Lexington, Va., will be held at Camp Jackson, Columbia, S. C., from August 1 to September 1. These are the only schools where there are artillery units. About 350 students will be in attendance, (*The Official Bulletin*, June 13, 1918, p. 9)

The Oldest French Engineer

On May 18, 1918, Jules Gaudry, a member of the French Society of Civil Engineers, celebrated his one hundredth birthday. Notwithstanding his great age he has all his faculties and attended the meeting of the French Society of Civil Engineers at which a special medal was presented to him.

It is an interesting fact that Gaudry started his life as a lawyer, having even been admitted to the Paris bar, but in the 40's of the past century he entered the Cavé shops and studied steam-engine construction. In 1849 he entered the service of the state railroads, where he remained until 1870.



Jules Gaudry

In 1876 he was appointed commissioner of accounts for the Trans-Atlantic Company, a position which he continued to occupy until 1906, or until he reached the age of 88 years.

In 1855 he was secretary of the Jury Commission in the general class of machinery at the famous Paris Exposition.

During the Franco-Prussian war of 1870-1871, Gaudry had the important task of acting as inspector of testing and construction of all kinds of artillery supplies, and by the time the siege of Paris by the Prussians ended he had succeeded in providing the complete material necessary for seventeen batteries.

The last paper read by Gaudry before the French Society of Civil Engineers, and bearing on the progress of engineering of water transportation, was at the age of 83 years.

British Parliamentary Commission on the Metric System

A final report has been presented to the British Parliament by the Committee on Commercial and Industrial policy after the War, which has been at work in the past two years. Chapter 10, dealing with Weights and Measures, presents the conclusions of the committee relative to the proposal for the compulsory adoption of the metric system. The 19 members were a unit in reporting adversely, and it is highly significant that this is taken to mean the dismissal of the metric-system proposal from consideration as a subject of legislation in Great Britain. Following are extracts from the report:

"Having given very full consideration to the subject, we are unable to recommend the compulsory adoption of the metric system in this country. In our opinion, it is absolutely certain that the anticipated uniformity could not be obtained for a very long period, if ever.

"There is, further, the serious objection that if we induced the above-mentioned countries to change over to the metric system, we should be surrendering to Germany the advantage which our manufacturers now enjoy over hers, both in their marks and our own.

"We are informed that even in France, which has made the metric system nominally compulsory for more than half a century, the 'pouce' (or inch) is used in textile manufacture, and numerous local measures still survive.

"In referring to these considerations, we have to point out that there is no unanimity even as to the theoretical merits of the metric system as compared with our own. The practical argument that its adoption is desirable in order to secure uniformity in the markets of the world has been shown to be unfounded. We are not satisfied by any evidence which has been brought before us that trade has actually been lost to this country owing to the fact that the use of the metric system is not compulsory.

"But to attempt to make the use of the system universal and obligatory in this country would cause loss and confusion at a particularly inopportune moment for the sake of distant and doubtful advantages. We are convinced that, so far from assisting in the reëstablishment of British trade after the war, such a measure would seriously hamper it.

"As regards the educational advantages claimed for the change, we have been referred to a statement quoted by the Select Committee of 1895 that no less than one year's school time would be saved if the metric system were taught in the place of that now in use. The information which we have received does not support that statement, and even if it were well founded, it must be remembered that for at least a generation children would have to learn both the new and the old measures and how to convert from one to the other.

"It is often popularly supposed that the introduction of the metric system would render possible the immediate sweeping away of many complicated and varying weights and measures. As we have already indicated, this belief is, in our opinion, wholly fallacious.

"We are not convinced that the metric system is, upon the whole, even theoretically superior to the British system, and we are satisfied that the practical objections to the proposed change are such as decisively to outweigh any advantages which are claimed for it." (*The Iron Age*, vol. 101, no. 21, May 23, 1918)

REVIEW OF ENGINEERING PERIODICALS

SUBJECTS OF THIS MONTH'S ABSTRACTS

For Articles on Subjects Relating to the War, see Aeronautics, Engineering Materials, Machine Tools, Munitions, Varia

Aeronautics (See also Internal-Combustion Engineering)

Stability of Aeroplanes, H. A. Webb. The writer considers the conditions of stability of an aeroplane, both in steady and disturbed flight, by the use of Newton's laws of motion and axes fixed in space. He does not discuss the practical consequences that follow from the loss of stability. It is of interest to note that the present writer does not use the usual mathematical convention, in which it is assumed that the aeroplane is travelling with a negative velocity.

The writer also gives two fundamental equations of longitudinal and lateral stability. The gyroscopic terms in the case of forward translation are claimed to be negligible, but it is stated that they may have an important effect on the stability of banked or spiral flights. (*Engineering*, vol. 105, no. 273, May 3, 1918, pp. 475-476)

Exhaust-Valve Troubles. As a result of reports of trouble on several occasions through the burning of exhaust valves or aero engines, the Rolls-Royce, Ltd., have carried out a series of experiments to determine the cause of this trouble and means for obviating it.

These tests have given some valuable results. Thus, it was found that the temperature of an exhaust valve in the hottest portion is 700 to 750 deg. cent. and the temperature of the exhaust gases in the exhaust port is approximately 700 deg. cent.

It was also found that the valve is hottest when the cylinder is working with the most efficient mixture, that is, when the maximum power is obtained with the minimum amount of fuel. Hence, the general impression that weak mixtures cause valves to get very hot was not borne out by these experiments. It was apparent that the effect the mixture had on the burning out of valves is controlled by the amount of free oxygen in the exhaust.

As regards the material used for valves, it appears that chromium steel has the advantage of not oxidizing at ordinary working temperatures. Tungsten-steel valves in ordinary conditions scale and gradually get thinner, but once the valve reaches the temperature at which burning commences the difference between the two kinds of steel is not appreciable.

The tappet clearance is of course directly affected by the elongation of the valve at normal working temperatures. Tests carried out showed that this elongation is 0.014 in. to 0.016 in. A set of valves were run with no clearance at all in the tappets when cold, so that at normal temperatures the exhaust valves did not seat by 0.015 in. The engine ran for 25 hours and the valves were in perfect condition when the test was finished. It was noticeable when the engine was running that the valves were the same heat all over, whereas in normal working conditions they all cooled on the seating where they come in contact with the cylinder. It was found that it was possible to run with the valves not seating by as much as 0.008 in. and still obtain a cooled ring round the outer ridge of the valves. It is assumed that in this case the valve is cooled by the thin volume of gas passing around the valve at a considerably reduced velocity and itself being cooled by contact with the seating of the cylinder. Investigation showed that with no tappet clearance in the exhaust valves when cold the power was reduced by 1.5 per cent, and, further, that it was possible to run with only 0.005 in. clearance with no loss of power. In carrying the tests still further, the tappets were adjusted so that the exhaust valves could never seat when cold by 0.01 in. As a result the power was reduced by as much as 15 per cent, and the exhaust valves became excessively hot. In these conditions it was distinctly noticeable that the valves were hottest on the outer ring and cooler towards the stem; this, of course, being the converse of the results with correct tappet adjustment. This test also revealed another interesting point in that the valve was found to be much hotter on the sector towards the top center of the cylinder. This is of particular interest, because when burning occurs in an exhaust valve it has apparently never been appreciated why a bite is taken out of one portion, leaving the rest of the seating in fairly good condition. During these experiments it was noticed that this bite always occurs on the sector just mentioned towards the top center where the valve gets hottest. In conjunction with this it was also found that if a valve is turning round while the engine is running it takes a very much longer time to start to burn. Immediately burning commences the valve ceases to turn.

The effect of preignition was found to be of the greatest importance. It is stated that the spark plug which preignites under ordinary running conditions causes the exhaust valve to run at an incandescent heat. It was found that preignitions are greatly influenced by the amount of lubricating oil in the combustion chamber. In fact, it is claimed that no case of preignition has ever been known in an overlubricated cylinder and it was proved by actual experiments that if a spark plug commenced to preignite this could be redeemed by squirting a little oil into the air intake. It was also proved that it was possible to inject a certain amount of oil without affecting the horsepower of the engine and still secure a reduction of the temperature of the valve.

The Rolls-Royce Company affirms that with reasonable care

there should be no preignition and the chief reason for its occurrence is, in their opinion, that the engine is run with the oil too cold.

It was also found in the course of tests that the water circulation has a very important effect on the overheating of exhaust valves. It was noticeable that if the water circulation is faulty the first part to be affected is the exhaust valve. If the failure of the water circulation causes the spark plug to preignite, which is natural, the valve is burned in a few minutes. They state that very encouraging results have been obtained by increasing the flow of water per minute through the cylinder jackets. (*The Auto-Motor Journal*, vol. 23, no. 19/805, May 10, 1918, pp. 338-339, *epA*)

A German "Mystery" Biplane—the H. W. Description of the so-called H. W. German biplane recently brought down on the French front.

The smash and subsequent fire did not leave much on which to base the reconstruction of the machine. Apparently, however, the biplane is a two-seater with staggered wings having a dihedral angle but no sweep back. The most characteristic element of construction is the tail, which is of the biplane form with the top plane considerably smaller than the bottom one.

The shape of the ailerons is not quite certain. One of the observers claimed that the tail planes are polygonal with the angles rounded off. It appears also that the fuselage is very deep and the top plane very close to it. This would give the rear gunner an opportunity to easily fire upwards. (*Flight*, no 487, no. 17, vol. 10, April 25, 1918, pp. 444-445)

The Story of the Liberty Motor. This article claims to give the true story of the Liberty motor. There are no facts which were not previously known in one way or another, but the whole article gives a very clear and consistent history of this interesting war development. (*Scientific American*, vol. 118, no. 22, June 1, 1918, pp. 500)

Conventions

National Coöperative Convention A. A. E. *Power*, vol. 47, no. 22, May 28, 1918, pp. 780-781.

Meeting of the National Machine Tool Builders' Association. *American Machinist*, vol. 48, no. 23, June 6, 1918, pp. 959-967.

Engineering Materials

Failure of Ductile Materials Under Fluctuating Stresses, H. A. Webb and W. H. Barling. The paper starts with a brief introduction and a summary of previous work on fatigue of materials under fluctuating stresses. The writer believes that

$$\text{Equivalent static stress} = \frac{2\ \text{(maximum stress)}}{1 + \dfrac{1}{2}\dfrac{\text{(minimum stress)}}{\text{(maximum stress)}}}$$

is well supported by experiment for ductile materials under fluctuating direct stresses, and by analogy with it suggests the following formula for ductile materials under more complicated conditions of loading.

Let s_1 and s_2 be the maximum and minimum shear stresses (s_2 may be negative) at a given point, in a given plane through that point; then the equivalent static shear stress at that point, and in that plane, is

$$S = \frac{2s_1}{1 + \dfrac{s_2}{2s_1}}$$

Taking as an example the crankshaft of an aero engine, the shaft is subjected, at any given section, to a fluctuating direct stress, p, due to bending and thrust, and a fluctuating shear stress, q, due to torque. Let p and q be represented on a polar diagram, as in Fig. 1.

Let p_1, q_1, and p_2, q_2, be two pairs of corresponding values of p and q, i. e., p_1 and q_1 occur simultaneously, and so do p_2 and q_2. We assume temporarily that p_1 and q_1 represent the limits of fluctuation, and on this assumption we shall find a formula for S. In theory, we ought then to apply the formula to read off from the polar diagram and choose the largest of all the values of S so obtained, as the "maximum maximorum." In practice, experience should enable us to guess from the diagram, as a rule, what values of p_1 and q_1, p_2 and q_2 are likely to give the largest value of S. Probably

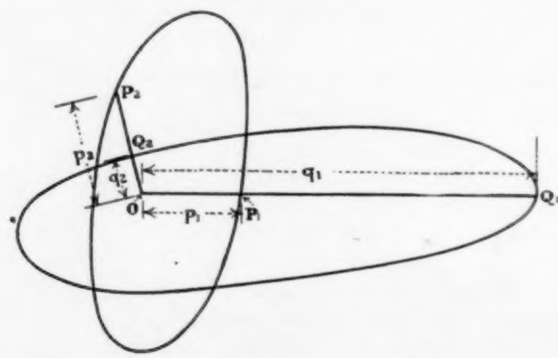


Fig. 1 Polar Diagram of Stresses on a Crankshaft of an Aeronautical Engine

we should not be far wrong, for a crankshaft, in taking the greatest and least values of q (the least value may be negative), together with the corresponding values of p, to determine the value of S.

We shall then prove that if

$$H = \frac{p_1q_2 - p_2q_1}{q_1^2 + \frac{1}{2}q_1q_2 + \frac{1}{4}p_1^2 + \frac{1}{8}p_1p_2} \quad \text{........[4a]}$$

is numerically greater than 1.414, then

$$S = \frac{2(p_1q_2 - p_2q_1)}{\sqrt{(q_1+q_2)^2 + \frac{1}{4}(p_1+p_2)^2}} \quad \text{..........[5]}$$

But if

$$H = \frac{p_1q_2 - p_2q_1}{q_1^2 + \frac{1}{2}q_1q_2 + \frac{1}{4}p_1^2 + \frac{1}{8}p_1p_2} \quad \text{........[4b]}$$

is numerically less than 1.414, then S either has the value given in [5], or it is equal to

$$\frac{2(q_1^2 + \frac{1}{2}q_1q_2 + \frac{1}{4}p_1^2 + \frac{1}{8}p_1p_2)^2 + (0.3)(p_1q_2 - p_2q_1)^2}{\left\{(q_1 + \frac{1}{2}q_2)^2 + \frac{1}{4}(p_1 + \frac{1}{2}p_2)^2\right\}^{3/2}} \quad \text{..[6]}$$

whichever is the greater numerically.

TABLE 1 DUCTILE MATERIALS UNDER FLUCTUATING STRESSES

p_1	q_1	p_2	q_2	S
23,000	4,600	12,300	0	20,200
3,600	12,000	0	4,800	20,300
12,500	10,000	7,500	5,000	19,500
12,000	5,000	6,000	−5,000	20,000
2,000	5,000	1,000	−5,000	20,400
2,500	7,500	0	−3,700	20,100
9,000	7,500	3,000	−3,000	20,100
12,000	6,000	−9,000	4,500	20,400

These formulæ are proven mathematically. This part of the paper is not suitable for abstracting.

The writer gives the following numerical illustrations: As a special case if $q_1 = q_2 = 0$, we find from [6] that

$$S = \frac{p_1}{1 + \frac{p_2}{2p_1}}$$

which agrees with [2] (as we should expect), since under a simple tension the maximum shear stress is half the tensile stress.

In the eight cases given in Table 1 the value of the equivalent static shear stress is about 20,000 lb. per sq. in., so that they are all, on this theory, about equally wrong. All the stresses are in pounds per square inch. (*Aeronautics*, vol. 14, no. 235, April 17, 1918, pp. 331-333, 3 figs., *tm*)

PRINCIPAL PROPERTIES OF ACIERAL. A new aluminum alloy under the name of acieral was placed on the market last year (for details of its composition see *The Iron Age*, April 5, 1917). Some tests of this metal have recently been made by the Bureau of Construction and Repair of the United States Navy, with results shown in Table 2.

These tests represent metal varying from 0.064 in. and up in thickness. (*The Iron Age*, vol. 101, no. 23, June 6, 1918, p. 1467, *e*)

TABLE 2 RESULTS OF TENSILE TESTS OF ACIERAL

Grade of alloy	Original area, sq. in.	Proportional limit, lb. per sq. in.	Ultimate strength, lb. per sq. in.	Elongation in 2 in., per cent	Reduction of area, per cent	Modulus of elasticity, lb. per sq. in.
A	0.0498	37,500	51,300	4.6	6.22	10,870,000
A	0.0498	37,000	49,400	2.0	4.62	10,000,000
B	0.0561	34,000	46,900	4.0	18.71	8,854,000
B	0.0561	35,000	45,800	3.1	16.85	8,700,000
C	0.0489	51,000	66,400	1.8	6.81	10,210,000
C	0.0495	51,000	67,600	4.1	7.28	10,640,000
D	0.0500	52,000	71,800	2.0	3.80	10,200,000
D	0.0500	54,000	69,000	2.0	2.80	10,525,000

ANNEALING AND RECRYSTALLIZATION OF COLD-ROLLED ALUMINUM SHEETS, Robert J. Anderson. The present article gives the results of a series of tests made on the effects of heat at different temperatures on the softening of cold-rolled sheet aluminum.

The main results of these tests have been reported in an abstract of another article by the same author in THE JOURNAL for June 1918, p. 506.

The present investigation, on the whole, shows that the existing general practice of annealing aluminum is faulty. The effect of long-time annealings, such as are common in present practice where sheets are exposed for, say, 24 hours at 375 deg. cent., is to cause an undue coarsening and weakening of the metal, evidenced by the coarse domes in the Erichsen test used in the present investigation.

Fabricating blanks which have been so annealed and which have undergone deep draws in the draw press also show the same coarse appearance at the edges of drawn shapes and this can be traced only to the long annealing period. (*Metallurgical and Chemical Engineering*, vol. 18, no. 10, May 15, 1918, pp. 523-527, 6 figs., *ep*)

THE ANNEALING OF CARBON STEELS AS AFFECTED BY VARIOUS TEMPERATURES AND MAGNETIC FLUX, R. B. Fehr, Mem.Am.Soc.M.E. The primary object of the investigation was to make a study of the range of temperature in which the various steel heat-treating operations should be carried out. For this purpose the critical range of temperatures was investigated through *small* intervals with the object of finding out what improvements would be brought about by better temperature control.

This research made it also possible to investigate whether there was any unusual effect on the physical properties of steel that was subjected to heat treatment and the action of magnetic flux simultaneously.

The main data of this investigation have already been reported from an advance publication of the paper in THE JOURNAL for January 1917, pp. 82-84. (*Pennsylvania State College Bulletin*, vol. 11, no. 11, October 1, 1917, *e*)

OCCLUDED GASES IN FERROUS ALLOYS, Gellert Alleman and Charles J. Darlington. Interest in occluded gases was aroused in the writers during an investigation conducted by one of them which had to deal with the bubbles formed around wire in wire glass. At first, it was assumed that these bubbles were composed of carbon dioxide and emanated from the glass itself, but subsequent work indicated the possibility of the gases coming from the metal of the wire.

A series of extensive tests was undertaken which gave some interesting data, summed up by the writers in the following manner:

1 We have constructed a gas-tight vacuum furnace, capable of continuous service at temperatures of approximately 1900 deg. cent.

2 By means of this apparatus, all the gases occluded in ferrous alloys may be removed and collected.

3 It appears that the gases are evolved in the following order: hydrogen is most readily set free, carbon monoxide comes next, and nitrogen seems to be held most tenaciously.

4 Whether oxygen is the result of the decomposition of various oxides of iron or the dissociation of carbon monoxide or carbon dioxide has not been determined.

5 We have shown that ferrous alloys may occlude relatively large volumes of gases—in some cases equal to about 200 times the volume of the metal.

6 We suggest that in addition to the ordinary functions of metals like aluminum, tungsten, chromium, menganese, titanium, silicon, etc., when placed in ferrous alloys these elements may act as catalytic agents and either prevent the occlusion of large quantities of gases or aid in the elimination of such gases at lower temperatures than would ordinarily take place.

7 We have shown that the removal of gases from ferrous alloys markedly changes the microstructure and increases the density of the alloy. (*Journal of The Franklin Institute*, vol. 185, no. 4, April 1918, pp. 461-480, 4 figs)

THE INFLUENCE OF SURFACE TENSION, F. C. Thompson. *The Iron Trade Review*, vol. 62, no. 12, May 23, 1918, pp. 1299-1304, 9 figs. Reprint of a paper presented at a recent meeting of the British Iron and Steel Institute. The hypothesis is offered for surface tension and bears an important influence on the structure of iron and steel.

THE DEFINITION OF HARDNESS, W. Cawthorne Unwin. The writer points out the interesting fact of the identity of the hardness numbers of Martel and Brinell. In view of the fact that Martel's work is comparatively little known, the following passage from the article is of particular interest:

In 1895 to 1900 Lieutenant-Colonel Martel communicated two very interesting and valuable papers to the Paris Congress on testing materials. He used the falling-monkey

method, with various forms of indenting points and various heights of fall. He established conclusively that the work expended in indentation, notwithstanding these variations of the conditions, is proportional to the volume of the indentation.

If V is the volume of the indentation, P the weight of the monkey and F the height of fall, $D = P\ F/V$ is constant for any given ductile material. Then D in kilogram-millimeter units is Martel's hardness number.

It is easy to see that D is the amount of work necessary to cause a cubic unit of indentation and is independent so far as the tests go of the form of the indenting body.

Further, a few tests were made with a gradually applied load and the same law was satisfied, except that D was about 20 per cent less in the case of a gradually applied load. Probably this was due either to there being some loss of work in vibrations, etc., in the impact test; or to inexactness in determining the work expended in tests by a gradually applied load. (*Engineering,* vol. 105, no. 2733, May 17, 1918, p. 535)

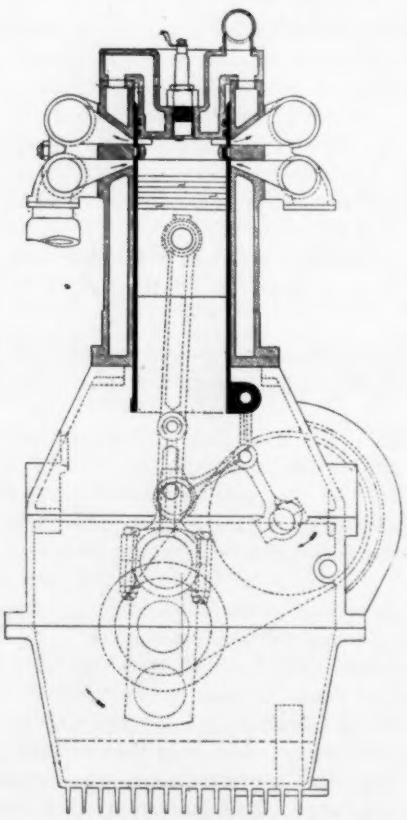


FIG. 2 SINGLE-SLEEVE-VALVE MOTOR

SUR L'HÉTÉROGÉNÉITÉ DES ACIERS, G. Charpy and S Bonnerot. *Revue de Métallurgie,* 15 Année, no. 2, March-April 1918, pp. 132-136, 4 figs. Discussion of the heterogeneous character of the structure of steel.

Fuel and Firing

THE STORAGE OF BITUMINOUS COAL, H. H. Stoek. *University of Illinois Bulletin,* vol. 15, no. 27, Engineering Experiment Station, Circular no. 6, March 1918, 192 pp.

FIRING WITH COAL DUST. *Engineering,* vol. 105, no. 2733, May 17, 1918, pp. 552-553. General discussion of the subject largely based on American practice.

FIGURING FURNACE-GRATE AREA. *Power,* vol. 47, no. 22, May 28, 1918, pp. 756-758, 7 figs.

LE SERVICE D'ÉCONOMIE DE COMBUSTIBLE À LA CIE DES FORGES ET ACIÉRIES DE LA MARINE ET D'HOMÉCOURT, M. Theodore Laurent. *Revue de Métallurgie,* 15 Année, no. 2, March-April, 1918, pp. 117-126, 1 fig. Description of methods of fuel economy employed in a French metallurgical plant.

ALCOHOL AS A MOTOR FUEL. Report by the Commonwealth Advisory Committee on Science and Industry presented to the Australian government on alcohol fuels and engines. The report considers in very favorable light the possibility of using alcohol as a fuel. For denaturants it recommends tar-oil distillates as being cheap, effective and having no corrosive effect on valves or cylinders. For Australian conditions the use of mixtures of alcohol with benzol or ether are not recommended. As regards the source of raw materials the report recommends the use of molasses, sorghum stalks, cassava and sorghum grain. (*The Autocar,* vol. 40, no. 1176, May 4 and 11, 1918, pp. 435-436, 459-460, 3 figs.)

Handling and Conveying

CONVEYOR SCHEME FOR NEW YORK'S "PACKAGE FREIGHT," M. A. Long. *Freight Handling and Terminal Engineering,* vol. 4, no. 5, May 1918, pp. 158-160.

Internal-Combustion Engineering (See also Railroad Engineering)

OIL-ENGINE SPRAYERS OR PULVERIZERS, A. H. Goldingham and T. C. O'Brien. *Motorship,* vol. 3, no. 5, May 1918, pp. 3-4, 10 figs.

SINGLE-SLEEVE-VALVE MOTOR. A new sleeve-valve engine is being developed by the S. S. V. Motor Company, of Pittsburgh, Pa., the design being due to Charles B. and James M. Gearing. A cross-sectional view of the engine is shown in Fig. 2.

The engine has four cylinders of $3\frac{1}{2}$ in. bore by 5 in. stroke, and a single sleeve is interposed between each piston and its cylinder wall. The sleeve, of course, reciprocates at one-half the speed of the piston, making one reciprocation during each complete engine cycle. Its travel is equal to 13-16 in. This makes a total travel of $1\frac{5}{8}$ in. during a complete cycle, as compared with 20 in. of piston travel. The sleeve is said to have a dwell corresponding to 275 deg., during which period the compression and power strokes take place. The ports in the cylinder wall and in the inner head are so arranged that the port in the sleeve is between the inlet and exhaust ports during this particular period.

When the crankshaft is 45 deg. from the bottom dead center on the power stroke, the sleeve moves up and begins to open the exhaust port. The latter closes at the top dead center. The inlet port is opened by a quick motion of the sleeve valve.

There are two inlet and two exhaust ports to each cylinder. The sleeve is positively operated by a double toggle combination, one link of which is driven by an eccentric shaft rotating at one-half crankshaft speed and the other half by an eccentric which is placed above the crankshaft and operated by means of the connecting rod so that it has an irregular angular motion. The upper end of the two links is connected by a third link to a lug on the sleeve.

The whole cylinder block is an aluminum casting, without special lining, as all of the wear comes on the inside of the sleeve. An experimental engine that has been built developed

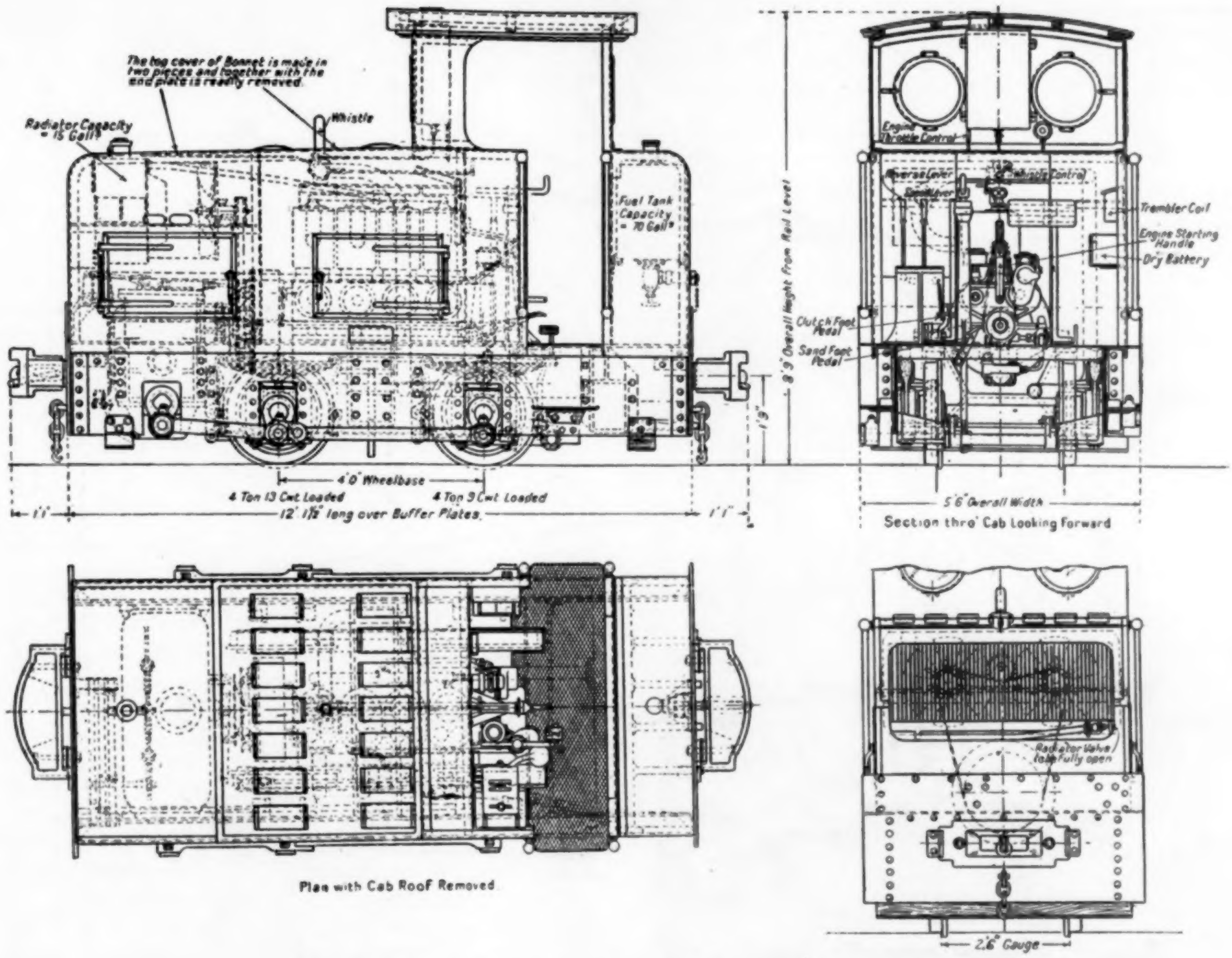


FIG. 3 BRITISH NARROW-GAGE INTERNAL-COMBUSTION LOCOMOTIVE

a torque of 110 lb. (length of brake arm not given) at 1400 r.p.m. The spark plugs are located centrally in the cylinder heads. This engine will run up to 2700 r.p.m., it has been definitely stated.

The exhaust ports have their top edge on a line with the bottom of the inner head and are 2 7-18 in. wide, measured circumferentially. They afford a very direct passage for the exhaust gases from the cylinder and this is believed to have a tendency to keep the cylinders free from carbon.

Lubrication is by the force-feed system, oil being fed under a pressure of 5 to 10 lb. per sq. in. to the three main bearings and through drill holes in the crankshaft to the crankpin bearings. Oil thrown off from the crankpin bearings lubricates all the other internal parts. The sleeve-operating shaft, as will be seen, is chain-driven. (*Automotive Industries*, vol. 38, no. 20, May 16, 1918, p. 953, *d*)

SMALL LOCOMOTIVES OF SPECIAL TYPES. The first of a series of articles describing small locomotives such as are used by contractors or for special purposes. The locomotives described are both steam and internal-combustion, the steam locomotives being of the fireless type.

As regards fireless locomotives, the one described is built by Hawthorn, Leslie and Company. A particular feature of the engine is a special superheater and steam drier which is claimed to effect a gain in efficiency ranging from 10 to 15 per cent, according to the charging pressure available and the pressure at which the reducing valve is set. It is said that it has been found that in order to obtain a perfectly satisfactory operation of reducing valves, it is necessary to provide an adequate volume of steam between the valve and the cylinders so as to act as a cushion on the reducing valve and prevent violent fluctuations in the pressure of steam in the delivery pipe. The superheater referred to here does it, and, in addition, also provides a reservoir of low-pressure steam, which is drawn upon for supplying the cylinders and, at the same time, allows the steam to become thoroughly dried before entering the cylinders for a period when the reservoir is at or about at its maximum pressure and corresponding temperature. The amount of superheat gradually decreases until the point is reached when the pressure in the reservoir corresponds with that at which the reducing valve is set. During the ensuing period of working, the reducing valve ceases to be operated and passes the steam directly from the reservoir to the cylinders at a gradually falling pressure.

The same firm builds an internal-combustion locomotive driven by a 4-cylinder marine-type engine designed to develop 55 b.hp. at 600 r.p.m. The power is transmitted through a friction clutch to a change-speed gearbox, arranged to give traveling speeds of 4, 8 and 15 miles per hour, both forward and backward.

The unit has a weight in full running order of 8.75 tons and runs on a gage of 2 ft. 6 in.

Another type described in the article is the narrow-gage internal-combustion locomotive built by the Avonside Engine

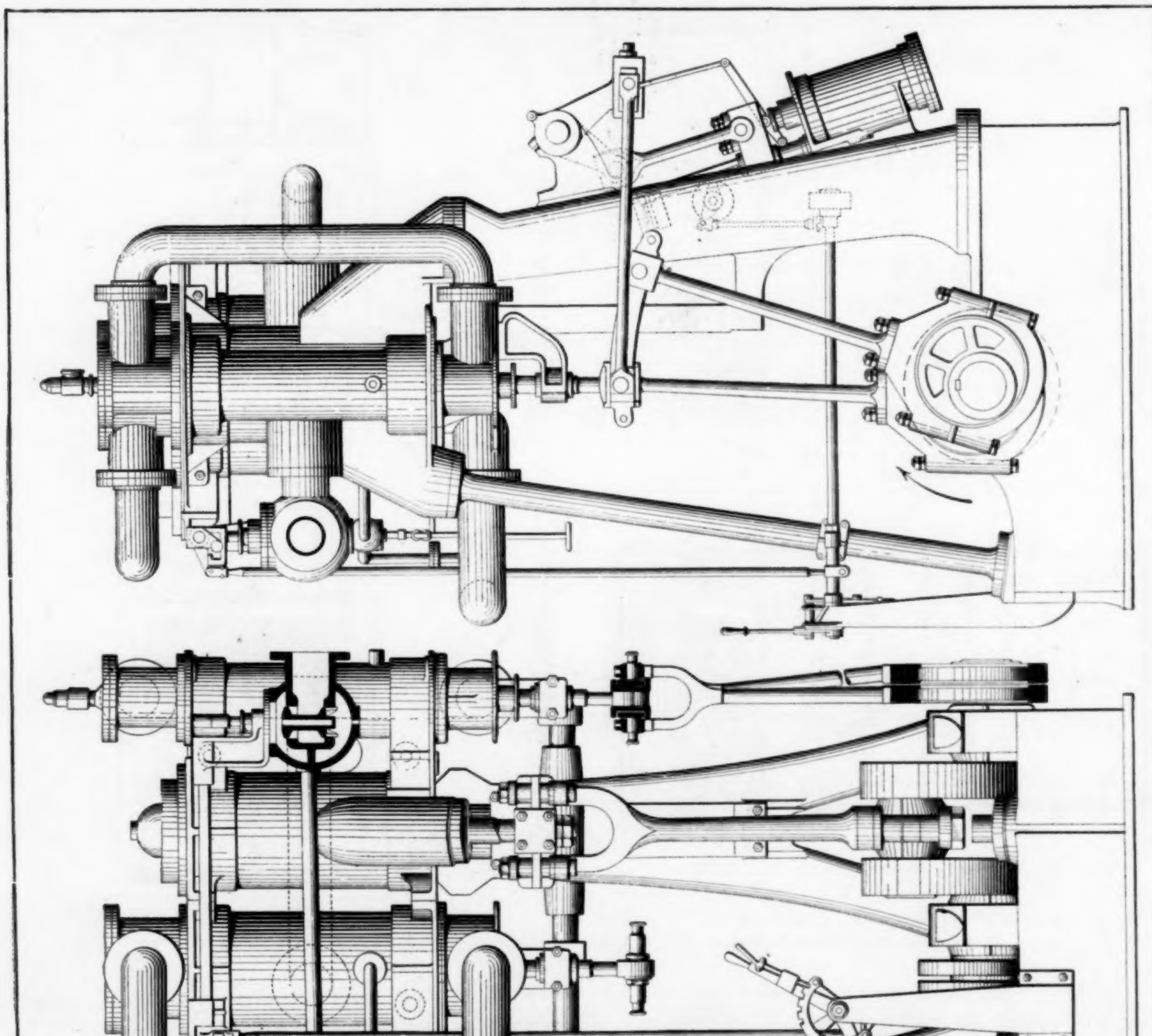


FIG. 4 GENERAL ARRANGEMENT OF THE EMERGENCY FLEET FORE-AND-AFT TRIPLE-EXPANSION ENGINES

Company at Bristol (Fig. 3). This locomotive is of the M. L. M. type; that is to say, it is from 55 to 60 hp., and is suitable for gages varying from 1 ft. 11⅝ in. to 5 ft. 6 in., the drawing here showing a 2 ft. 6 in.-gage locomotive.

There are four wheels 2 ft. in diameter and coupled, the wheelbase being 4 ft. The total weight loaded is 9 tons and 2 cwt., 4 tons 13 cwt. being on the front axle and 4 tons 9 cwt. on the rear axle.

The motor is of the four-cylinder (6½ in. by 8 in.) vertical type, designed to run normally at 550 r.p.m. The power is transmitted through a clutch and change-speed gearbox, no chains being used. The engine is designed to work on any ordinary kerosene having a flash point up to about 150 deg. fahr. It is started from cold by running on gasoline for a few minutes and changing over to kerosene. (*The Engineer*, vol. 125, no. 3255, May 17, 1918, pp. 419-421, 5 figs., *d*)

Machine Tools

Bullard Maxi-Mill Boring Mill. Description of a boring mill embodying in its construction some features which are stated to have never before been applied to a machine of this type.

In the new mill such standards and complete units as the drive, feed works, spindle construction, rail construction have been embodied with only minor changes, but new features also appear.

In the bed the gears and bearings are flooded with oil at all times.

A new form of centralized control has been introduced. The crank handles were eliminated on the hand wheels, these being of the hammer type, which is claimed to make possible very fine settings of the tools.

Graduated scales mounted on the face of the cross rail and on the tool slides give the coarser readings, while micrometer dials graduated to thousandths and equipped with Bullard observation stops give the final readings.

Another feature of construction claimed to be new permits the use of large and effective amounts of cutting lubricant on the tool. In fact, the machine was designed with this in mind from the start and it is claimed that the construction is such as to avoid the possibility of the cutting lubricant entering parts of the machine where it is not desired. (*American Machinist*, vol. 48, no. 23, June 6, 1918, pp. 973-974, 4 figs., *s*)

Marine Engineering

Ljungström Turbo-Electric Ship-Propelling Machinery. *Engineering*, vol. 105, no. 2731, May 3, 1918, pp. 489-491, 9 figs. (serial).

Hydraulic Equipment of a Modern Shipyard, J. H. Rodgers. *Canadian Machinery and Manufacturing News*, vol. 19, no. 20, May 16, 1918, pp. 505-509, 9 figs.

Design and Progress of the Floating-Frame Reduction Gear, John H. Macalpine. *Proceedings of the Engineers' Society of Western Pennsylvania*, vol. 34, no. 1, February 1918, pp. 1-38, 21 figs., 2 tables.

The Hull Weight of Cargo Ship, H. Hashiguchi. *Journal of the Society of Naval Architecture*, vol. 22, April 1918, pp. 60-74 (in Japanese).

The Stokes Wave and Trochoidal Deep Sea Waves, Prof. S. Yokota. *Journal of the Society of Naval Architecture*, vol. 22, April 1918, pp, 74-79 (in Japanese).

Suction and Repulsion Between Two Ships Based on Model Experiments, H. Makita. *Journal of the Society of Naval Architecture*, vol. 22, April 1918, p. 79 (in Japanese).

The Turbo-Electric Ship "Wulsty Castle"—Controlling Resistances. *The Engineer*, vol. 125, no. 3255, May 17, 1918, pp. 423-426, 6 figs.

Emergency Fleet Engines. In view of the great interest naturally felt by American engineers in propelling machinery of the Emergency Fleet ships, there is reproduced on the opposite page from *Power* a cut showing the general arrangement of the fore-and-aft triple-expansion engine built for the Corporation by the Buckeye Engine Company.

It is of 700-hp. capacity and has a 15½-in. diameter high-pressure cylinder, a 26-in. intermediate and a 44-in. low-pressure cylinder with a stroke of 26 in. Piston valves are to be used on all cylinders and are $7\frac{1}{16}$, $14\frac{1}{16}$ and 15 in. in diameter, respectively, and 3 ft. $\frac{13}{16}$ in. long.

The columns on which the cylinders are secured are 7 ft. 1 in. high and 7 ft. wide at the base. The frame consists of a front and back column. The front column is 4½ in. in diameter and the back column is of A-shaped form when looked at from the forward end. These columns carry the guide bars.

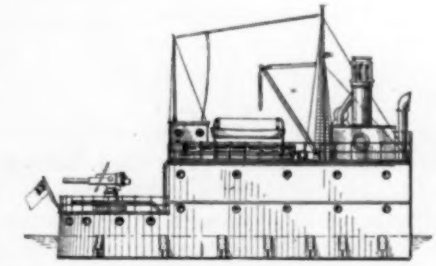


Fig. 5 Diagram of a Large Poop-Type Detachable Ship Electromobile When Not Attached to the Ship

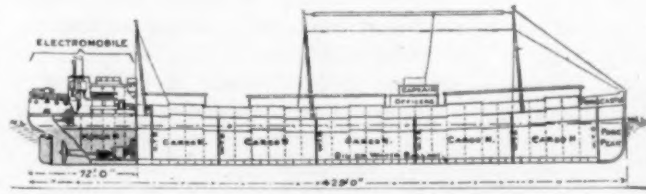


Fig. 6 Cargo Ship of 10,000 Tons Deadweight Carrying Capacity on the Snell Electromobile System

The crankpins are 8½ in. and the wristpins 4½ in. in diameter. The shaft is 8⅜ in. in diameter and the cranks are placed at 120 deg. apart. (*Power*, vol. 47, no. 23, June 4, 1918, pp. 794-795, 2 figs., *dA*)

Snell System of Electric Propulsion for Ships. The Snell system of electric propulsion is to be used in particular for ships operating under such conditions that the time of loading and unloading is considerably greater than the time during which the ship is under way. This applies in particular to cross-channel navigation.

Instead of a complete set of machinery in each ship, the Snell system provides one set of transferable power-producing machinery so constructed as to be attachable to several independent hulls. Only propellers and electric motors, which form a small proportion of the total cost of machinery, are fixed in the hulls themselves and are connected during the voyage to the power-producing machinery by electric cables.

The hulls of the ships may be similar to those of ordinary cargo steamers, the space usually occupied by engine and boilers being available for cargo. The power-producing plant will consist preferably of internal-combustion engines or high-speed steam turbines driving alternators, the whole enclosed in a detachable structure of special design carried on the stern or amidship of the hull and firmly attached thereto during the voyage.

Such a detachable "electromobile" with Diesel engines of 4500 b.hp. is shown in Fig. 5, while a cargo ship with the electromobile attached is shown in Fig. 6.

It is claimed that this system insures greater safety against torpedo attacks, as the hull is practically independent of the machinery. Even if it be seriously damaged, the ship, with its machinery intact, would have a good chance of making port. Further, as the electromobile is to be constructed so as to have flotation of its own when not engaged in propelling ships, the machinery portion may be saved even should the hull be so damaged as to cause it to sink.

It does not appear whether any ships on the Snell system have been actually built, the whole matter being quite new. (*Snell Economic Ship*, January 1918, 1 4pp. and 2 plates, *d.*)

Measurements

VARIANCE OF MEASURING INSTRUMENTS AND ITS RELATION TO ACCURACY AND SENSITIVITY, Frederick J. Schlink, Mem.Am. Soc.M.E. Instrumental variance, which forms the major part of the discussion of this paper, is a factor whose effect in causing error in measuring instruments has hitherto been given but little consideration. In order to bring out the essential relations of the variance characteristic, the paper opens with a discussion of accuracy and sensitivity, showing how each of these terms can be given precise definition with definite numerical significance. Such values when determined have important use in establishing the figure of merit or value of a given instrument or type of instrument. A distinction is drawn between the commercial accuracy commonly called for in direct-reading instruments of the shop and plant, and the higher grade of accuracy required in the laboratory where instrumental indications are normally subject to the application of corrections for error of calibration.

A definition of sensitivity of an instrument is of real significance only when there are means for expressing it numerically. It is suggested that the unit of response for an instrument should be based upon a definite and inherent characteristic of that instrument rather than upon some accidental factor, such as the length of a pointer or an arbitrarily graduated scale.

The paper shows the necessity for distinguishing between insensitiveness and passiveness or sluggishness in an instrument, and consideration is given to the effect of friction in preventing response to certain small changes in the measured quantity. The paper gives the following definition of sensitivity:

Sensitivity in an instrument is the rate of change in the indicating of such instrument with respect to the change in the quantity being measured, it being necessarily assumed for the purpose of this definition that friction and lost motion in the mechanism have been eliminated or are negligible.

The amount of the least alteration in the value of the measured quantity, producing instrumental response, divided by the initial value of the measured quantity may be called the passivity of the instrument at that point. Passiveness is a special case of the phenomenon of variance, next discussed. Variance is defined as the range, at any given value of the measured quantity, of variation in reading which may be exhibited by the instrument under repeated application of the same value of the quantity being measured, after a steady reading has been attained—the environment remaining unchanged.

The specific variance or variancy may be defined as the ratio of the range, at any given value of the measured quantity, of variation in reading which may be exhibited by the instrument under repeated application of the same value of the quantity being measured, divided by the measured quantity itself, the same assumptions applying as above as to the attainment of a steady state of indication and as to the maintenance of unchanged environment.

Determination of the variance is a most important part of the calibration of an instrument and appreciable error may arise from failure to recognize or express it.

The paper illustrates the derivation of the variance from a certain hysteresis loop and discusses in detail the phenomena occurring in the measuring instruments used therefor. It also analyzes in detail the possible sources of inaccuracy and shows, among other things, that the phenomena usually ascribed to the operation of friction of resistances only may be due to more complicated causes.

The frequency-curve method of delineation is applied to the expression of variance of an irregular nature, as found in instruments exhibiting bad workmanship or ill repair, and it is seen that the variance characteristic of such an instrument can be completely defined by reference to a family of frequency curves obtained in the following manner: One series of points will be plotted for readings taken at varying rates and amounts of increase of the measured quantity terminating in the value corresponding to the particular point of the scale under investigation, and another set for decreasing values terminating at the same point. Such a curve, in which frequency of occurrence of a particular reading or error is plotted against the true value of the measured quantity at that reading, gives the probability of occurrence of any amount of variation from, say, the mean instrumental reading.

Far from being a relatively unimportant source of inaccuracy in measuring instruments, it can be shown that the hysteresis or variance type of error demands consideration in practically every type of instrument, while in some (such as pointer-and-dial types of displacement indicators) it is a preponderating factor in design and actually limits the application or utility of the instrument and sets the limit of sensitivity and accuracy practicably to be obtained.

A few means of reducing instrumental variance are given, including the use of special types of bearings in which slack or clearance can be reduced to a minimum without impairing easy operation; and the use of flexible elastic connectors between elements of the linkwork instead of gears and racks or pin-and-link connectors. Such tape-like connectors which may wind on cam-shaped members to provide for correction of displacements to a linearly graduated scale, exhibit excellent properties in the matter of reversibility of calibration, and have important advantages over the more usual types of linkwork details.

The action of vibration in reducing instrumental variance is found in accord well with the principles previously set down, and it appears that, within limits, errors of result due to mechanical sources of variance can be considerably reduced by judiciously applied vibration treatment.

In designing and constructing an instrument, due consideration should be given to the effect of variance errors in

practically limiting the sensitivity to be sought in adjustment, as well as the interval between the graduations and the smallness of the units of graduation. It is suggested that in view of this condition, the mean interval of graduation of laboratory instruments should not be less than five times the mean variance, while for commercial or plant instruments the ratio of mean scale interval to mean variance may be of the order of two to one. Likewise the sensitivity may easily be disadvantageously high, inducing erroneous estimates of the precision of results and requiring special care in the calibration and use of the instrument.

The factors of maximum or mean inaccuracy (or accuracy), sensitivity, variancy and special set (the amount of which the variance loop may fail of closure, divided by the range of the deflection cycle) may be referred to the total range of graduation instead of to particular values of the measured quantity under observation, as a convenient means of arriving at single significant numbers to be composed into a "figure of merit" for an instrument whose characteristics are being determined. (Abstract of Scientific Paper now in press, U. S. Bureau of Standards.)

The Spinning Top in Harness. *Engineering,* vol. 105, no. 2733, May 17, 1918, p. 553, 2 figs. Abstract of a lecture given before the Royal Institution of London on May 3 by Sir George Greenhill. The lecturer discussed the general phenomena of gyrostatic action with particular application to practical uses in automatic control of such rapidly moving apparatus as flying machines and torpedoes.

Devices for Comparing the Rotation of Shafts, Prof. K. Suyehiro and T. Tsuchiya. *Journal of the Society of Naval Architecture,* vol. 22, April 1918, pp. 39-40 (in Japanese).

Object of Measuring CO_2 in Chimney Gas and New CO_2 Recorder, I. Naito. *Journal of the Society of Naval Architecture,* vol. 22, April 1918, pp. 48-60 (in Japanese).

The Electric Dynamometer, C. F. Scott. *Aviation,* vol. 4, no. 9, June 1, 1918, pp. 596-598, 2 figs.

Milling-Machine Dynamometer. Description of a dynamometer specially designed for use on the milling machine, by R. Poliakoff, Mem.Am.Soc.M.E. The general design of the instrument is shown in the accompanying illustration, Fig. 7. It is adapted to measure the pressure exerted in milling cuts resolved into three components, each one at right angles to the other two. In this respect it goes much further than the usual machine-tool dynamometer.

Its operation is substantially as follows: The instrument is mounted on a foundation plate *A*, which rests upon the table of the milling machine and is attached thereto by bolts in the usual manner. The work to be milled is placed on the auxiliary table *B* and made fast thereto. The work and milling cutter are then brought together and the cut started.

The resulting pressures exerted on the work upon the table *B* may be resolved into three components.

Referring to Fig. 7, the horizontal arrow pointing in the right-hand direction indicates the direction of one of these components. The vertical arrow pointing downward toward the table indicates a second component. The direction of the third is parallel with the surface of the table at right angles to the other two. So the resultant pressure can be split up into three components and each is registered on a separate gage of the instrument. Two of these gages are shown in Fig. 7. The pressure is transmitted by causing a flow of liquid to register accurately upon the gages the amount of the pressure in each of the three directions.

The instrument is adapted to determine the pressure required for various milling operations, and thereby assist in determining the strength of the parts of milling machines or to analyze the action of various types of cutters or the degree of difficulty for cutting the various materials. (*Machinery,* vol. 24, no. 10, June 1918, p. 932, 4 figs. *d*)

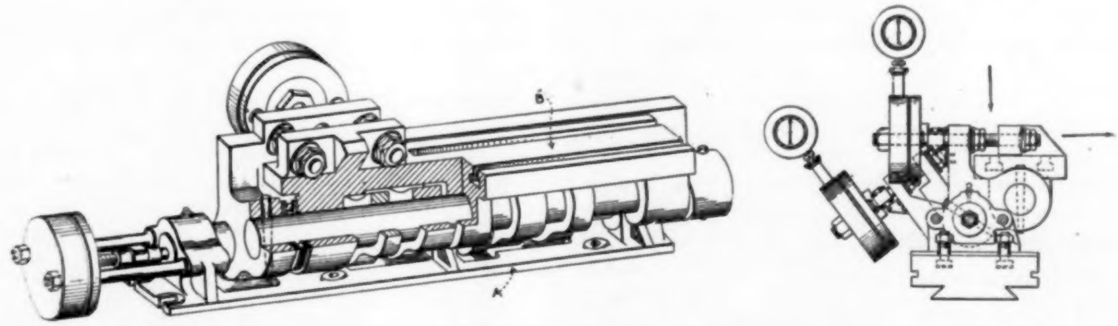


Fig. 7 Maching-Tool Dynamometer

Mechanics

Leaf Springs, Their Capacity for Dissipation of Energy, C. P. Schwarz. The writer discusses the potential dissipation of a spring, or its ability to dissipate energy when subject to shock. He gives expressions for this energy which depend entirely upon the structure of the spring and which would express the amount of heat dissipated by the spring as soon as the value of a certain coefficient is experimentally determined.

The analysis of the expressions derived by the writer discloses some interesting facts. The dissipation increases in the same ratio as the product of the thickness of the leaves and their number, not counting the master leaf. That is really the height of the spring. Locomotives which require springs with high dissipation have springs composed of numerous leaves of very substantial thickness.

The dissipation decreases with the length of the master leaf; if, however, all leaves are made of the same length ($= 2\ L$) the dissipation is doubled.

When a maximum of dissipation has to be accompanied by a minimum of weight the semi-elliptic spring is unexcelled. The three-quarter elliptic, platform, and full elliptic spring follow in the order enumerated. The cantilever spring is theoretically equal to semi-elliptic. However, it must be provided with a "dead" end for anchoring purposes, and then its weight efficiency is reduced.

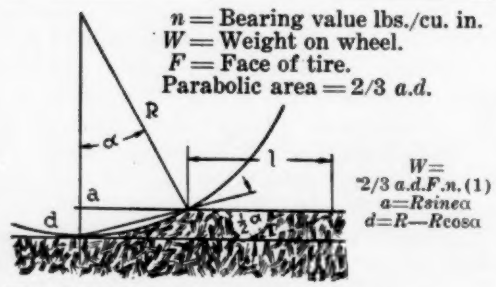
To increase the dissipation until a practically satisfactory

periodicity is reached two main avenues of development are open to us, leading to:

1 Thin leaf spring

2 Spring with inserts.

(*The Automobile Engineer,* vol. 8, no. 114, May, 1918, pp. 141-142)



$$W = 2/3Fn\,(R^2\text{sine}\,\alpha - R^2\text{sine}\,\alpha\cos\alpha)$$
$$= 2/3FR^2n\,(\text{sine}\,\alpha - \tfrac{1}{2}\text{sine}\,2\alpha)$$
$$\frac{W}{2/3FR^2n} = \text{sine}\,\alpha - \tfrac{1}{2}\,\text{sine}\,2\alpha \qquad (2)$$

FIG. 8 RESISTANCE TO ROLLING OF A HARD CYLINDRICAL BODY

Mean unit pressure $= \frac{W}{FR\text{sine}\alpha}$

$= 2/3$ maximum unit pressure.

$\therefore$ Max. unit pressure $= 3/2\ \frac{W}{FR\text{sine}\alpha}$

Which varies as depth from zero at the surface.

$\therefore$ Work per unit area $=$

$$d \times \tfrac{1}{2} \times 3/2\ \frac{W}{FR\text{sine}\alpha}$$

Work of depression over distance 1 with resistance P *is* $\tfrac{3}{4}\ \frac{W}{FR\text{sine}\alpha}\,dF1 = P1$

$\therefore \frac{P}{W} = \tfrac{3}{4}\ \frac{d}{FR\text{sine}\alpha} = \tfrac{3}{4}$ slope of chord

$= \tfrac{3}{4}\tan\tfrac{1}{2}\alpha$

or $G = \frac{P}{W} = \tfrac{3}{4}\tan\tfrac{1}{2}\alpha$ (3)

FIG. 9 EQUATION FOR THE EFFECT OF DEPRESSION OF SOIL THROUGH A BODY ROLLING UPON IT

It can be shown that

$$\text{Cos}\,\alpha = \sqrt{\frac{2P}{FR^2n}} - 1$$
$$d = R - R\cos\alpha$$
$$d = \sqrt{\frac{2P}{Fn}} \qquad (5)$$
$$P = \tfrac{1}{2}d^2Fn \qquad (6)$$

Or resistance depends upon depth of depression, face of tire and soil factor, irrespective of diameter and weight.

Knowing the soil flow and bearing value, P could be determined from the track alone.

FIG. 10 FACTORS DETERMINING THE MAGNITUDE OF RESISTANCE TO ROLLING

RESISTANCE TO ROLLING OF TRACTOR WHEELS IN SOFT GROUND, Amos F. Moyer, Mem. Am.Soc.M.E. Preliminary report of a research conducted with financial assistance from the University of Minnesota Research Fund and from the Society of Automotive Engineers to determine the relation between rolling resistance, specific load, wheel diameter, speed, and other factors.

The mathematical derivations which it was proposed to verify by these experiments were based on the assumption that soft soil and probably other plastic materials bore up a unit pressure proportionate to the depth of depression. This is equivalent to saying that the total weight borne up is proportionate to the volume perpendicularly enclosed by the displacing surface in actual contact with the substance and below the surface from which the substance was displaced.

In the case of a hard cylindrical body rolling on a level plastic surface this volume consists of prismatic half-segments of the cylinder below the level surface and on the forward side, but, if the deforming body, instead of being a cylinder, were rounded upward in front and continued flat for some distance backward, as in the case of a sled runner or caterpillar tread, the supporting volume of displacement would include also the rectangular prism extending backward a distance equal to the flat supporting surface, which explains the greater carrying capacity of surfaces of this kind. The experiments thus far conducted were confined to plain, flat-tired wheels of varying weight, width and diameter.

In Fig. 8, Equation 1 expresses approximately the low outline for a cylindrical body for plain, flat-tired wheels, where n is the load supported by the soil per unit volume displaced. From this is deduced Equation 2, which expresses a similar law in terms of the wheel dimensions and the arc α which is in contact with the soil.

Fig. 9 gives equations derived through the application of the principle of conservation of energy, by virtue of which it must be true that the work done in rolling a wheel a given distance is equal to that expended in depressing the soil over the same distance.

In Fig. 10, P represents resistance, or pull required to roll the wheel, and this divided by the weight of the wheel is G, or Equivalent Grade, which is the percentage grade, such that if the wheel rolled upward without friction on a hard surface it would give the same resistance as P.

The value given here, or $\tfrac{3}{4}\tan\tfrac{1}{2}\alpha$, or three-quarters of the slope of the chord subtending the arc of contact, is a much smaller quantity than some of the data previously published on loss in rolling a round wheel would lead one to believe.

Referring again to Equation 2 in Fig. 8, it is evident that the factors in the denominator other than n are proportional to the cylindrical volume of the wheel, which may be called Q. In the calculations this has been expressed in cubic feet, so that W/Q, which is designated as S, or specific load, is written in pounds weight per cubic foot of wheel volume, and the writer proves mathematically that there is a fixed relation between S and G whenever n remains constant. He also shows that resistance depends upon the depth of depression, face of tire and soil factor, but is independent of diameter and weight. Hence, knowing the soil flow and bearing value, P can be determined from the track alone. In other words, if we know anything about the soil, that is, if we know n, we can tell the resistance of a wheel even if we never have seen anything but the track.

The writer proceeds then to describe the apparatus used in the tests and the method of carrying them out, which indicates the considerable amount of work spent in the present investigation.

This attaches considerable interest to the question whether the values of n found in the present investigation actually

represent weight borne per cubic inch of soil displaced, or merely a hypothetical something which will satisfy a complicated equation. On obtaining data on the actual displacement of soil there was no means at hand for ascertaining the "wave" action in front of the advancing wheel, and merely the volumes were calculated which were below the original soil surface. This "wave" action and the small bank of loose earth which always forms in immediate contact with the tire reduce the value of n, but this happens to be obtained also by the mathematical determination of n from S and G, which would indicate that the mathematical determination of n automatically takes into account several variables which apparently would be difficult to determine by measurement. When the laws of variation of n are once determined, the values thus established will give true values of resistance, since resistance is the quantity whence they are derived. (*Automotive Industries*, vol. 38, no. 20, May 16, 1918, pp. 949-953, *e*)

New Theory of Plate Springs, David Landau and Percy H. Parr. The paper starts with a survey of the previous work on the theory of plate springs and from this proceeds to the consideration of such theory, and description of experiments carried out by the writers.

The new theory is based on the consideration that any leaf of a spring, except a short plate, has a beam *encastré* at one end, loaded at the other, and having a flexible support somewhere between the point of encastrement and that of application of the load.

The writers derive an equation expressing the fundamental relation between the lengths of the leaves and their corresponding reactions of tip pressures. Among other things, this equation shows that the strength of a spring is not nearly in direct proportion to the number of plates, and also explains why the endurance at a given deflection decreases with the increase in the number of leaves.

The writers claim that the fundamental reason for the failure of the old theory is that it ignores the clamping of the leaves at the center of a semi-elliptical spring or at the end of a cantilever spring, this effect of the clamping being sufficient to vitiate the old theory to such an extent as to render it useless from both the theoretical and practical points of view.

The question of the permissible load that any spring may safely carry according to the new theory is discussed in detail. The writers claim that a two-leaf spring has 1.6 times the strength of a single-leaf spring.

The following two general laws are formulated with regard to non-tapered leaf springs:

1 In any leaf spring having leaves of equal cross-sections, and with equal steps, the reactions or pressures between the leaves continually decrease from the short leaf toward the master leaf, as do likewise the stresses.

2 In any leaf spring having leaves of equal cross-sections, and in which the reactions or pressures between the leaves are equal, the steps or overhangs continually decrease from the short leaf toward the master leaf. (*Journal of The Franklin Institute*, vol. 185, no. 4, April 1918, pp. 481-508, 9 figs., 6 tables.)

Stresses in Bolts in Fulcrum Brackets. *The Railway Gazette*, vol. 28, no. 20, May 17, 1918, pp. 579-581, 8 figs.

Motor-Car Engineering

A Remarkable French Tractor, the Theillier-Mesmey. *The Auto*, no. 907 (no. 21, vol. 23), May 24, 1918, pp. 371-374, 3 figs.

Munitions

Ordnance Tools Present Problem, Col. H. W. Reed. *The Iron Trade Review*, vol. 62, no. 23, June 6, 1918, pp. 1425-1426.

An Equation to Express Fair Return, Wm. G. Raymond. *The Railway Gazette*, vol. 28, no. 20, May 17, 1918, pp. 578, 2 tables.

Developments in Artillery During the War, John Headlam. *Journal of the Washington Academy of Sciences*, vol. 8, no. 10, May 19, 1918, pp. 301-319.

Hydraulically Operated Shell Production Machinery, I. William Chubb. *American Machinist*, vol. 48, no. 23, June 6, 1918, pp. 939-943, 12 figs.

Relation of Locomotive Maintenance to Fuel Economy, Frank McManamy. *Railway Review*, vol. 62, no. 21, May 25, 1918, pp. 752-754.

Some Important Points in Design of Truck Bolsters, Louis E. Endsley. *Railway Review*, vol. 26, no. 20, May 18, 1918, pp. 735-741, 17 figs.

Safety Engineering

Grain-Dust Explosions, B. W. Dedrick and David J. Price. Investigation of conditions under which carbonaceous dusts became explosive carried out in the experimental attrition mill at the Pennsylvania State College.

Under the term "carbonaceous dusts," in this investigation, in addition to coal dust, are comprised other types of dusts now known to be inflammable and capable of propagating flame, such as dust in flour and feed mills, grain elevators, threshing separators, etc.

The investigation conducted was undertaken for the determination of possible causes of explosions and the testing of various preventive measures suggested. It was carried out along very broad lines, but only the features of interest to mechanical engineers are briefly abstracted here.

In the original article the results are presented in the form of tables and the experimental installation used and methods employed are described in detail.

As regards the explosibility of various grains, it was found that elevator dust flour, wheat scourings and malt sprouts seem to produce explosions the most consistently, while oat hulls do not appear to give very inflammable mixtures unless they contain a considerable amount of fine dust.

From the tests on the action of static electricity, it appears that, at least in the case of the attrition mill, any static electricity that may be generated is dissipated so rapidly by leakage, which is due to the relatively high atmospheric humidity (Pennsylvania) that no potential is built up in the frame of the machine. Further, it appears to be comparatively difficult to ignite inflammable dusts in an attrition mill by means of static electricity. Nevertheless, every precaution should be taken to eliminate static electricity in the operation of any kind of mill, one good method being the grounding of the machine.

The moisture content of the material appears to have an important bearing on its inflammability. The less moisture the dust contains the more inflammable it is likely to be, and it is probable that there is a maximum moisture content above which the dust cannot be ignited.

Revolving dampers and relief valves as a means of prevention for the propagation of explosions were tried. Both were found of some value. In particular, it was found that a double

revolving damper does not appear to serve the purpose of a fire trap any better than a single damper. (*U. S. Department of Agriculture Bulletin,* no. 681 (also *Bulletin* no. 26 of the *Engineering Experiment Station of Pennsylvania State College*) May 18, 1918, 54 pp., 5 figs., bibliography appended, *ep*)

Steam Engineering

CAPITALIZATION VALUE OF STEAM LEAKS, R. Von Fabrice. *Power,* vol. 47, no. 19, May 7, 1918, pp. 656-658, 1 chart.

SOME NOTES ON TURBINE BEARINGS AND THEIR LUBRICATION, Charles H. Bromley. *Power,* vol. 47, no. 21, May 21, 1918, pp. 734-736. An interesting collection of data taken from the author's loose-leaf notebook.

BOILER SETTINGS—CHAIN GRATE STOKERS, Chas. H. Bromley. One of several articles on boiler settings for various boilers and types of stokers most suitable for the different coals. The chief purpose of the articles is to assist those in the Middle West and Northwest who are confronted with combustion problems by reason of the zone system for the distribution of bituminous coal enforced by the Fuel Administration. Several excellent chain-grate settings are shown in this article. (*Power,* vol. 47, no. 23, June 4, 1918, pp. 788-792, 6 figs.)

BOILER SETTINGS, Chas. H. Bromley. Data on boiler settings for various stokers under different kinds of boilers adapted to high-volatile coal. The writer claims that secondary arches are sometimes superfluous. Thus, secondary arches on Stirling boilers of the usual class are far from the fire and cannot exert an appreciable performance upon the fuel bed. It is therefore of no help in coking the coal, unless the grate is run too fast. This may explain the gradual abandonment of the secondary arches on these boilers. In some settings, however, a secondary arch may be useful for mixing the air and gases, provided the bridge wall is continued high enough to form a narrow passage between the end of the bridge wall and the end of the secondary arch. (*Power,* vol. 47, no. 22, May 28, 1918, pp. 760-762, 3 figs., 2 tables)

CONCRETE BOILERS NEXT. Now, according to the San Francisco *Chronicle,* cement may be used in the construction of boilers in the near future, as it is understood that an experiment will be made at the Union Iron Works. The report says that considerable figuring has been done and numerous sketches have been made, and that a boiler will be constructed shortly. It is stated that it is expected that with the exception of the boiler shell there will be but little change, and instead of one thick boiler sheet the new construction of shell is to consist of two thin sheets of steel, probably ¼-in. in thickness, and these will be fastened together, leaving between them 2 or 3 in. of space, which will be filled with a high-grade cement. (*Power,* vol. 47, no. 23, June 4, 1918, p. 808)

NOTE SUR LA CORROSION DES TUBES DES CONDENSEURS PAR SURFACE ALIMENTÉS À L'EAU DE MER, G. Costeseque. *Revue Générale de L'Électricité,* 2 annee, tome 3, no. 18, May 4, 1918, pp. 647-650. Discussion of the corrosion in surface-condenser tubes supplied with sea water as a cooling medium.

TUBE FAILURE IN WATER-TUBE BOILERS. An editorial presenting in an interesting manner a survey of the general state of our knowledge on tube failure in water-tube boilers. The article properly emphasizes the fact that water-tube explosions generally result in more damage to human life and health than to property, and that every precautionary measure available should be applied to minimize these accidents. (*Power,* vol. 47, no. 21, May 21, 1918, pp. 739-740.)

DESIGN AND LAYOUT OF CONDENSERS, D. D. Pendleton. *The Iron Trade Review,* vol. 62, no. 22, May 30, 1918, pp. 1361-1365, 5 figs. Paper presented at the recent meeting of the Engineers' Society of Western Pennsylvania. A practical discussion on the subject of selection of condenser equipment under various conditions, and the importance of providing the installation with proper auxiliaries.

SUPPORTING EFFECT OF BOILER HEADS, Neil M. Macdonald. The writer discusses the question as to whether the strength of the unbraced head should be added to the strength of the stays to find the allowable pressure in a boiler, especially in one of large dimensions and operating under high pressure.

In particular, and by way of illustration, he examines the case of a 72-in. by 18-ft. horizontal tubular boiler having a distance of 26 in. between the top of the tubes and the shell plate.

The area to be braced in this case is the area of a segment enclosed by lines drawn 3 in. from the shell and 2 in. from the tubes, or an area of 936 sq. in.

For the strength of the unbraced flat head he uses the Nichols formula, which, while experimental, is sufficiently accurate for the purpose. For a boiler head ½-in. thick and a material having a tensile strength of 55,000 lb. per sq. in. this formula gives a safe working pressure of 37 lb. per sq. in., so that if the boiler was to be designed for a safe working pressure of 125 lb. per sq. in. and the strength of the unstayed head be added, the bracing would be sufficient if good for $125 - 37 = 88$ lb. In accordance with this theory, if the factor of safety on the unbraced head was 8 and on the braces 6, the bursting pressure on the braced head would be $(37 \times 8) + (88 \times 6) = 824$ lb. per sq. in. The writer shows that this is absolutely wrong and that the real bursting pressure of the head is only the value of the strongest portion, which, in this case, is the braces, and is $88 \times 6 = 528$ lb. per sq. in., which gives a safe working pressure of 88 lb. per sq. in.

The writer, in his discussion, compares what happens in the boiler to the case of two walls joined by a rope fastened so that it cannot slip and capable of withstanding any pull up to 528 lb. As soon as the pressure rises above 296 lb., which is more than the weaker wall can stand by itself, the only thing that holds the wall from collapsing is the staying power of the rope. But when the pressure reaches 528 lb. the rope breaks, allowing the full load of 528 lb. to come on the weaker wall, and, as the latter can stand only 296 lb., both the rope and the wall must let go. This explains the case of the boiler with unstayed head.

The same argument applies to the staybolted furnace sheet of a vertical tubular boiler with the slight difference when the furnace sheet proper is stronger than the staybolts. It also applies to the stay bolting of a cone top in a submerged vertical tubular boiler and to the flat firebox sides of a locomotive-type boiler. The writer sums up the subject by stating that a braced or staybolted portion of a boiler is no stronger than its strongest part, and on no account should the strength of the braces or staybolts be added to the strength of the plate and their sum considered the strength of that portion of the boiler. (*Power,* vol. 47, no. 21, May 21, 1918, pp. 733-734, *g*)

STRESSES IN TURBINE BLADING, Gerald Stoney. The blading in steam turbines is exposed not only to stress due to centrifugal force, but also to stress due to pressure of steam on the blades, and to vibratory stresses.

The stress due to centrifugal force is nearly a function of the weight of the blade and speed of rotation and is a steady stress. The writer gives formulæ for the centrifugal stress in brass and steel blades and asserts that due regard in considering it must be had to the fact that in some types of blade fixing the strength of the fixing is less than the tensile strength of the blade, and often the blade is cut away at the root to provide for the blade fixing. Furthermore, in some types of construction the yield point at which the blade begins to draw out of its fastening is reached considerably before the yield point of the material of the blade, which is especially liable to occur with blades of brass or other alloy which have a much higher coefficient of expansion than the steel of the turbine rotor. (In this connection, more data are given below.)

The next stress on the blades is that due to the pressure of the steam on the blades, which is also the force that drives the turbine. The writer indicates a method which has been found convenient in practice.

In designing a turbine the following quantities, among others, are generally known:

R = revolutions per minute

Q = maximum pounds steam per hour

$\alpha = u/c$ = velocity ratio or ratio of blade speed u to steam speed c in feet per second

η_i = blade efficiency.

In his calculations the author introduces also the unit of blade width, w, that is, width of a row of blading measured axially in the turbine. In this way he shows that the force on each blade is:

$$t = \frac{Q\eta_i Rbw}{168\alpha^2} \times 10^{-5} \ldots\ldots\ldots\ldots\ldots [3]$$

where b is a constant depending on the type of blading (in impulse blading b is generally between 0.5 and 0.6 and in reaction blading it is between 0.6 and 0.7).

If Z is the resistance modulus of the blade section when 1 in. wide and f_s is the stress on the blades due to steam pressure, then the moment is $f_s Z w^3$, and is equal to $\frac{th}{2}$ Putting this value for t into the above equation, we have:

$$\frac{h}{w^2} = 336 \times 10^6 \, \frac{\alpha^2 f_s Z}{Q\eta_i Rb} \ldots\ldots\ldots\ldots\ldots [4]$$

Values of $\frac{\alpha^2}{\eta_i}$ for impulse blading for various values of α derived from Fig. 11 are given in Fig. 12. Strictly speaking, these should be corrected for leakage; but in neglecting this correction we are keeping on the safe side, and in a modern turbine the leakage is small. This seems a difficult equation to work with; but in practice it must be remembered that usually the velocity ratio and blade shape are constant throughout the whole or a large part of the turbine, and therefore α, η_i, b and Z are constant; so that

$$\frac{h}{w^2} = C\,\frac{f_s}{QR} \ldots\ldots\ldots\ldots\ldots\ldots\ldots [5]$$

The total tensile stress on the blade is then given by $f = f_s + f_c$; and here a distinction must be made between the strength of the blade and the strength of the way in which it is fixed into the rotor; in other words, of the blade fixing.

The stress due to steam pressures in the blade, or f_s, causes bending of the blade, and this combined with the centrifugal force f_c gives the stress which must be allowed for at the weakest section of the root of the blade. On the other hand, so far as pulling the blade out of the rotor is concerned, only the centrifugal force f_c must be taken into account.

As regards the factors of safety, much higher factors must be allowed for the stresses due to bending where there is pressure admission on account of intermittent action of the steam. In the case of partial admission the value of h/w^2 must be multiplied by the proportion of the circle occupied by nozzles. Actually, the suitable blade widths can be seen at once when the blade heights are known.

The writer mentions another method applicable when partial admission is used and the velocity of the steam is above the critical velocity. This method is based on the formulæ of Rankine and Rateau, namely, that the flow of steam in pounds per second is approximately proportional to the absolute pressure in pounds per square inch.

The writer believes that the cutting away of the sides of the blades for fixing them into a dovetail curve in the rotor weakens the blade against bending stress much less than might be supposed. In fact, he claims that in some cases this cutting away even increases its theoretical stress, as the resistance modulus of the blade action $Z = I/\sigma$, where I is the moment of inertia of the blade and σ is the distance of the

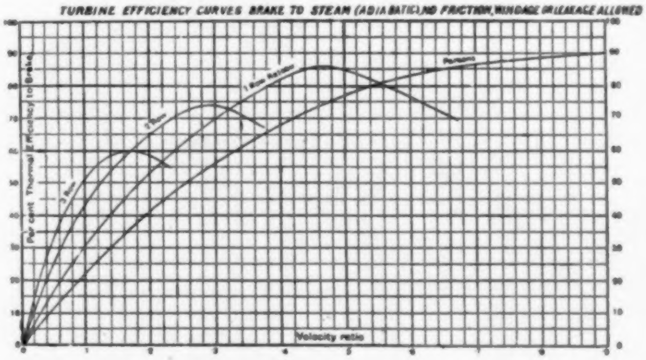


FIG. 11 TURBINE EFFICIENCY CURVES

edge of the blade through the center of gravity. Cutting away the edges reduces σ largely, and I only a little, as the edges are thin, so that a certain amount of cutting away actually increases the strength of the blade. In practice, however, the amount of cutting away is so large (in order to provide sufficient bearing surface to take a centrifugal force) as to weaken the blade.

In the preceding discussion which applied to impulse turbines, only the tangential force on the blades has been considered, while the axial force parallel to the axis of the turbine and due to drop of pressure in the moving blade has been neglected, since in impulse turbines it is generally small in amount.

But in reaction or Parsons blading the drop of pressure across the moving blades is considerable and the axial stress large, in fact, under ordinary conditions is equal to or rather more than the tangential.

With such blading where there is equal expansion of the steam in the fixed and moving blades we have the equation

$$t = \frac{Q\eta_i Rbw}{84\alpha^2} \times 10^{-5} \ldots\ldots\ldots\ldots\ldots [7]$$

for the tangential force only. Here α is the true velocity ratio or the ratio of the blade speed to the steam speed in either the fixed or the moving rows. In some books the velocity ratio is taken as if the whole of the expansion were in the fixed row, as in the impulse turbine, this latter velocity being, therefore, $1/\sqrt{2}$ of the above value of α.

Let T be the tangential force on the blading and L the axial,

Δp being the drop of pressure across either moving or fixed row, and V the volume of steam in feet per second.

$$T = \frac{2\eta_1 V \Delta p}{u}$$

and

$$L = A.\Delta p$$

A being the area of the annulus. Therefore:

$$\frac{T}{L} = \frac{2V\eta_1}{uA} = \frac{2\eta_1 \sin\theta}{\alpha} \ldots\ldots\ldots\ldots\ldots\ldots [8]$$

since V/A = axial velocity of the steam, or $c \sin\theta$, θ being the blade angle; and the forces on each blade have the same

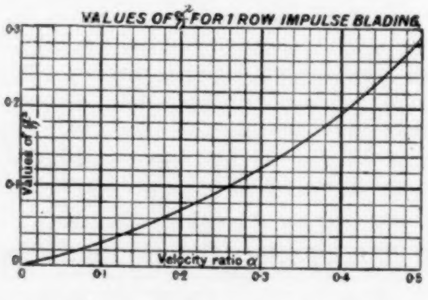


FIG. 12 $\frac{\alpha^2}{\eta}$ FOR IMPULSE-TURBINE BLADING

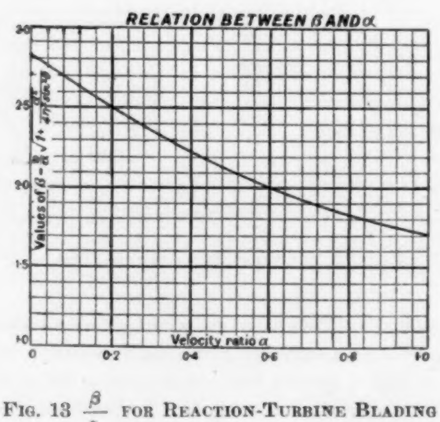


FIG. 13 $\frac{\beta}{\alpha}$ FOR REACTION-TURBINE BLADING

ratio. The resultant force on the blade, n, is then the resultant of these two forces, or:

$$n = t\sqrt{1 + \left(\frac{\alpha}{2\eta_1 \sin\theta}\right)^2}$$

$$= \frac{QRbw\eta_1}{84 \times 10^6 \alpha^2}\sqrt{1 + \left(\frac{\alpha}{2\eta_1 \sin\theta}\right)^2}$$

Calling

$$\frac{\eta_1}{\alpha}\sqrt{1 + \left(\frac{\alpha}{2\eta_1 \sin\theta}\right)^2} = \beta$$

$$n = \frac{QRbw}{84 \times 10^6 \alpha}\beta \ldots\ldots\ldots\ldots\ldots\ldots [9]$$

From this it follows that:

$$\frac{h}{w^2} = 168 \times 10^6 \frac{f_s Z\alpha}{QRb\beta} \ldots\ldots\ldots\ldots\ldots [10]$$

Fig. 13 gives the relation between β and α, derived from Fig. 11, θ being taken as 20 deg.; and since, of course, the minimum value of α in any section of the turbine must be taken, it is seen that between the values of $\alpha = 0.4$ and $\alpha = 0.6$, which are the usual minimum values in modern turbines, the value of β is 2.15, so that:

$$\frac{h}{w^2} = 78 \times 10^6 \frac{f_s Z\alpha}{QRb} \ldots\ldots\ldots\ldots\ldots [11]$$

which gives the total stress on the blades due to the combined effect of pressure drop and reaction.

Hitherto no account has been taken of the stiffening effect of the shrouding or lacing of the blades. This is because shrouding riveted on to the top of the blades cannot be considered rigid for small movements. Shrouding would increase the strength of the blade if it could be rigidly fixed to the blades by silver soldering or bracing, but this is difficult to accomplish. (*Engineering*, vol. 105, no. 2730, April 26, 1918, pp. 447-448, 3 figs., *ta*)

Thermodynamics

LOSSES OF HEAT THROUGH ENGINEERING AND BUILDING MATERIALS, R. B. Fehr, Mem.Am.Soc.M.E. Report on the thermal testing plant at the Engineering Experiment Station of the Pennsylvania State College.

This plant was designed and built for the purpose of studying the loss of heat through various engineering and building materials. Thus far the plant has produced data on the total transmission in various materials and has emphasized the importance of studying the effect of velocity, humidity and surface resistance. The following program of experiments with the present apparatus was adopted:

1 Study of temperature gradients through glass
2 Calibration of corkboard test box (5 ft. cube)
3 Transmission of heat through glass
4 Transmission of heat through air spaces formed by building paper.

The writer gives brief résumé of the theory of heat transmission and a rather elaborate description of the apparatus, methods of testing and method of calibration of the corkboard box.

As regards the results themselves, it appears that in the case of glass, as well as other poor insulators, practically all high resistance is to be found in the so-called surface resistance. It appears also that in spite of their entirely opposite insulating properties corkboard and glass exhibited a rather remarkable agreement in their value of k_1 (radiation and convection effect of surface on warm side or surface transmission in B.t.u. per 24 hours per sq. ft. per degree difference), k_2 (surface transmission on cool side), and K (total surface transmission for both sides), the values at 70 deg. difference of temperature being respectively, 59, 43 and 25 for corkboard and 90, 46 and 30 for glass. The higher values for glass are probably due to its smooth surface and transparency to radiation from within the test box.

Rather interesting tests were carried out on air spaces formed by building paper. The curves in the lower half of Fig. 14 show that there is an appreciable increase in the value of u, which is transmission in B.t.u. per 24 hours per sq. ft. per deg. fahr. with increase of temperature difference, as was also found by the Bureau of Standards. The curves in the upper part of Fig. 14 were obtained by plotting the values of the lower half as percentages of the fall of u for one layer of paper at a particular temperature difference. These curves show that for the ordinary differences of temperature found in heating and refrigerating and for ½-in. dead air spaces, the total transmission varies inversely as the number of layers of paper; in fact, the transmission falls off more rapidly, the statement implies, and, therefore, the rule will give results on the safe side for insulation problems.

The gradual approach to the theoretical curve (derived from

the above rule) as the temperature difference increases, leads to the conclusion that for temperature differences higher than, say, 100 deg. fahr., the greatly increased effect of radiation would render this simple rule useless. This fact is in line with the one recently established by the Bureau of Standards that for high-temperature insulation air spaces are not as effective as solid walls, because of transparency of air to radiation. Nevertheless, the writer comes to the conclusion that properly arranged inexpensive air spaces can be made as effective as the same thickness of the best insulating material on the market.

Attention is also called to the following conclusions:

1 More attention should be given to the matter of surface resistances, which, in the cases of glass or other poor insulators, constitute practically the total resistance.

2 The velocity of the air on the warm side of the wall probably exerts as much influence on the total surface resistance as the velocity of the air on the cool side.

3 The total surface transmission (both sides) for corkboard, glass and building paper, in the usual ranges of temperature for conditions involving slight air movements, is not far from 25 to 30 B.t.u. per 24 hours per sq. ft. per deg. fahr., and in the case of poor insulators rises to about 50 for a moderate velocity on the warm side and a higher velocity (1000 ft. per min.) on the cool side. (Report on the Thermal Testing Plant for 1916-1917, *The Engineering Experiment Station Bulletin No. 24, The Pennsylvania State College Bulletin*, vol. 12, no. 4, February 15, 1918, 25 pp., 6 figs., *ep*)

Varia

Neville Island Gun and Projectile Plant. The proposed plant will be built and operated for the Government by the U. S. Steel Corporation and will be in charge of a new organization called the U. S. Steel Corporation Ordnance Department, with John Ries, chairman, and L. E. Thomas, chief engineer.

One of the great problems in connection with the building of the new plant is that of securing labor and of housing the many hundreds of men who will be engaged for two years or more on construction work. Tentatively, it is proposed to establish a model town at the lower end of Neville Island with houses for employees of the arsenal as well as for operating officials at the plant. It is not unlikely that one or two bridges will be built across the Ohio River to connect Neville Island with the tracks of the Pennsylvania Lines West, and it is possible that one or two bridges will be erected across the back channel of the Ohio River connecting the island with the Pittsburgh and Lake Erie tracks.

Nothing has been determined so far as to the number and size of the steel works or other units that will be built, there being one stack now with a capacity of 450 tons per day; neither has the number of electric and open-hearth furnaces been determined at yet. (*The Iron Age*, vol. 101, no. 21, May 23, 1918, pp. 338-339, 1 fig.)

The Metric System for the British Empire, Arthur J. Stubbs. *The Post Office Electrical Engineers' Journal*, vol. 11, pt. 1, April 1918, pp. 1-18.

Against the Metric System. *The Iron Age*, vol. 101, no. 21, May 23, 1918, p. 1327.

Emergency Construction Work Due to War Conditions, with Especial Reference to the Construction Division of the Army, Geo. W. Fuller. *Proceedings of the American Society of Civil Engineers*, vol. 44, no. 5, May 1918, pp. 615-685, 3 figs., 10 tables.

Silicon and Carbon. *Engineering*, vol. 105, no. 2733, May 17, 1918, p. 552. Discussion of the chemical relations of these two elements, to a certain extent from the standpoint of comparison.

Charts

Horsepower per Revolution for Cast Iron and Cast Steel Gears for Both Cast and Cut Teeth, C. L. Miller. *The Coal Industry*, vol. 1, no. 5, May 1918, p. 170.

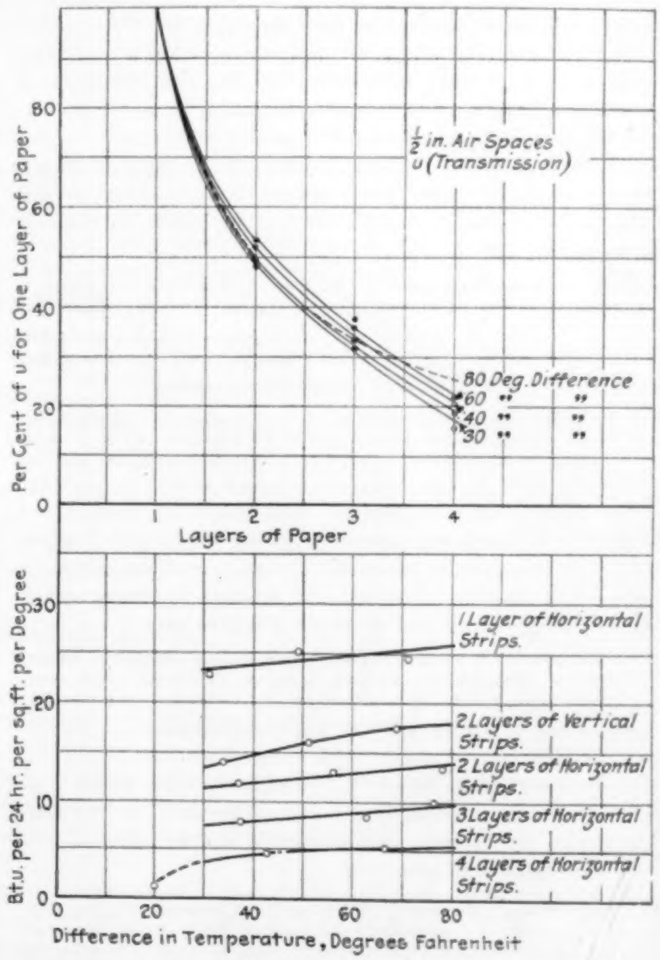


Fig. 14 Total Transmissions for ½-in. Air Spaces

Chart Showing Very High Pressures in Spray Valves of the Pump-Injection Type. *Motorship*, vol. 9, no. 5, May 1918, p. 4.

Chart Showing Pressures Recorded in the Combustion-Space and Cylinder at the Same Time as the Oil-Injection Pressures. *Motorship*, vol. 3, no. 5, May 1918, p. 4.

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society. The Editor will be pleased to receive inquiries for further information in connection with articles reported in the Survey.

LIBRARY NOTES AND BOOK REVIEWS

ARTICLES of interest from the Library of the four Founder Societies, selected list of accessions during the month, and reviews of books of special importance prepared by members of the A.S.M.E. and others particularly qualified.

BOOK NOTES

The Chemical Analysis of Iron. A Complete Account of All the Best-Known Methods for the Analysis of Iron, Steel, Pig-Iron, Alloy Metals, Iron Ore, Limestone, Slag, Clay, Sand, Coal and Coke. By Samuel Alexander Blair. Eighth Edition. J. B. Lippincott Co., Philadelphia, 1918. Cloth, 6x9 in., 318 pp., 102 illus., 2 tables. $5.

In this work the aim of the author has been to assemble in a single volume descriptions of the various methods and special apparatus which have been shown to be of real value to the iron analyst. Since the appearance of the seventh edition, in 1912, so many improvements have been developed in methods and the alloy metals have become so increasingly important that it has been found necessary practically to rewrite the book to bring it down to date. The table of atomic weights gives the values recommended by the Committee for 1918, and the table of factors has been revised to correspond with the new values.

Analysis of Financial Statements. By Richard P. Wilson and Harry J. Carpenter. La Salle Extension University, Chicago (copyright 1918). Paper, 6x9 in., 38 pp., 4 illus.

In this book the methods and principles of these analyses are described and illustrated by typical examples.

The Automobile Repairman's Helper. A Pocket Book for the Mechanic, Owner, Chauffeur and Student. By S. T. Williams. U. P. C. Book Co., Inc., New York (copyright 1918). Flexible cloth, 5x7 in., 438 pp., 322 illus. $2.50.

The object of the compiler has been to give the best method of doing each particular job of repairing and also to explain the proper sequence in which the various operations should be done. The methods described are thought to cover every trouble likely to be found in all the standard cars.

A Bibliography of Municipal Utility Regulation and Municipal Ownership. By Don Lorenzo Stevens. Harvard University Press, Cambridge, 1918. Cloth, 6x9 in., 410 pp. $4.

An extensive bibliography of material published in English, brought down to the end of 1916. Covers electric, gas, water and traction utilities, listing the material which the author considers of practical value, after an extensive study of the field. The entries are classified and annotated, and an index of subjects and authors is provided.

The Coal Catalog. Combined with Coal Field Directory for the Year 1918, Containing Explanatory Articles on Rank, Usage, Analysis, Geology, Storage and Preparation of Coals, together with a Typical Section of the Productive Formation of Each Coal Mining State in the Union, Maps Showing the Various Mining Districts or Fields, Descriptions of the Seams Mined . . . List of Seams Producing Coal Suitable for Each Industrial Purpose, etc., and a Directory of all the Coal Mines in the United States. . . . Keystone Consolidated Publishing Co., Inc., Pittsburgh (copyright 1918). Cloth, 9x12 in., 671 pp., 90 illus., 25 maps. $25.

A remarkably complete compendium of the coal industry of the United States and Canada, in which is collected the information needed by producers and users.

Digest of Publications of Bureau of Standards on Electrolysis of Underground Structures Caused by the Disintegrating Action of Stray Electric Currents from Electric Railways. Prepared by Samuel S. Wyer. Paper, 7x10 in., 96 pp.

Summarizes by verbatim quotations the essentials of the extensive laboratory and field investigations on this subject which the Bureau of Standards has published up to August 22, 1916. The quotations selected have been classified, and the compiler has added editorial notes. Copies may be procured from the Bureau of Standards, Washington, D. C.

Direct Costs of the Present War. By Ernest L. Bogart.

The Early Effects of the European War Upon the Finance, Commerce, and Industry of Chile. By L. S. Rowe. (Carnegie Endowment for International Peace, Division of Economics and History. Preliminary Economic Studies of the War). Oxford University Press, New York, 1918. Paper, 7x10 in.

These two pamphlets, belonging to a series of economic studies of the effects of the European War, and undertaken by the Carnegie Endowment for International Peace, discuss separate phases of the question. Professor Bogart's summary of the cost of the war to each participant covers only the direct financial outlays of the governments, compiled from the best available reports. Dr. Rowe gives an account of the immediate effects of the war in the period of the fall of 1914 and the spring of 1915, based on a personal investigation during the latter year.

Dyke's Automobile and Gasoline Engine Encyclopedia. Treating on the Construction, Operation and Repairing of Automobiles, and Gasoline Engines. Also Trucks, Tractors, Airplanes and Motorcycles. By A. L. Dyke. Seventh edition, revised and enlarged, containing dictionary and supplements on the Ford, Packard and airplanes. Published by the author, St. Louis, Mo. (copyright 1918). Cloth, 7x10 in., 864 pp., 515 charts. $3.50.

Presents in clear, simple and concise form the principles upon which gasoline engines and automobiles are built and operated. Sections are included on repairing, adjusting and driving, together with much miscellaneous information of value to automobile engineers and drivers. Over three thousand illustrations accompany the text.

Elements of Machine Design. By Henry L. Nachman. First edition. John Wiley & Sons, Inc., New York, 1918. Cloth, 6x9 in., 244 pp., 275 illus., 22 tables. $2.

A classroom text on the subject of elementary machine design, for students in technical institutes.

Elements of Sanitary Engineering. By Mansfield Merriman. Fourth edition, revised with the assistance of Richard M. Merriman. John Wiley & Sons, Inc., New York, 1918. Cloth, 5x9 in., 250 pp., 47 illus., 17 tables. $2.

A textbook intended to present the subject clearly in the smallest possible space, and to give greater prominence to fundamental principles than to details of construction and operation. The present edition has been revised, and fourteen new pages of text have been added.

Employment Department and Employee Relations. By F. C. Henderschott and F. E. Weakly. La Salle Extension University, Chicago (copyright 1918). Paper, 6x9 in., 60 pp., 20 illus., 4 tables.

Suggestions based on methods in use by various corporations. Contents: Selection of the Employee, the Labor Supply, Promotions and Transfers, Progressive Scale of Promotion Based on General Intelligence Requirements, Employee Records as a Basis for Promotion, Annual Survey of Employees, the Principle of Transfer, the Vocational Laboratory, Job Analysis, Labor Turnover, Educational and Welfare Work.

A Handbook of Rocks. For Use without the Microscope. With a Glossary of the Names of Rocks and of other Lithological Terms. By James Furman Kemp. Fifth edition, revised. D. Van Nostrand Co., New York, 1918. Cloth, 6x10 in., 272 pp., 41 illus., 75 tables. $1.50.

Professor Kemp has attempted to avoid the difficulties usually met by students, by mentioning and emphasizing only those characteristics which a beginner with preliminary training in mineralogy can observe and grasp. An extensive glossary is included in the work.

Eye Hazards in Industrial Occupations. A Report of Typical Cases and Conditions, with Recommendations for Safe Practice. By Gordon L. Berry. National Committee for the Prevention of Blindness, New York, 1917. Paper, 6x9 in., 145 pp., 51 illus. $0.50.

A survey of the hazards to the eyes in industrial occupations in the United States, with recommendations and suggestions for minimizing them.

General Lectures on Electrical Engineering. By Charles Proteus Steinmetz. Fifth edition, compiled and edited by Joseph LeRoy Haden. McGraw-Hill Book Co., Inc., New York, 1918. Cloth, 6x9 in., 242 pp., 50 illus., 1 por., 1 table. $2.50.

A series of descriptive, non-mathematical lectures on the problems of the generation, control, transmission, distribution and utilization of electric energy. The present edition has been largely rewritten to include the changes that have taken place in the electrical industry during the last eight years.

How to Become a Wireless Operator. A Practical Presentation of the Theory of Electrical Waves, their Propagation, and their Adaptation to Wireless Communications, including Simple and Clear Instructions on how to operate Wireless Devices and how to comply with Government Requirements for Operators. By Charles B. Hayward. American Technical Society, Chicago, 1918. Cloth, 6x8 in., 298 pp., 196 illus., 1 pl., 9 tables.

This work does not discuss the history nor the mathematics of radiotelegraphy, but is intended for those wishing to become proficient operators. Designed for individual study.

An Introduction to Statistical Methods. A Textbook for College Students; a Manual for Statisticians and Business Executives. By Horace Secrist. The Macmillan Co., New York, 1917. Cloth, 5x8 in., 482 pp., 28 pl., 95 tables. $2.

A study of the principles governing the collection, analysis, and synthetic treatment of numerical data, intended to supply the need for a fundamental treatment of the methods of statistical investigation and interpretation. The methods discussed are of general application, and are accompanied by illustrations drawn chiefly from economic and business fields. The treatment is non-mathematical.

Machine Design. A Manual of Practical Instruction in Designing Machinery for Specific Purposes, Including Specifications for Belts, Screws, Pins, Gears, etc., and many Working Hints as to Operation and Care of Machines. By Ernest L. Wallace. American Technical Society, Chicago, 1918. Cloth, 6x8 in., 157 pp., 90 illus., 2 pl., 9 tables.

A simple treatment of the subject, adapted for home study and intended for use by machinists, draftsmen and apprentices.

Manual of Forestry for the Northeastern United States. Being Vol. 1 of Forestry in New England revised. By Ralph Chapman Hawley and Austin Foster Hawes. Second edition. John Wiley & Sons, Inc., New York, 1918. Cloth, 6x9 in., 281 pp., 64 illus., 80 tables. $2.

The first of the two volumes dealing with the specific forestry problems of New England, but applicable also to conditions in neighboring states. This volume presents, in the simplest and least technical form possible, a brief survey of the whole field of forestry, for the use of woodland owners.

Metal Statistics 1918. Eleventh annual edition. The American Metal Market Co., New York (copyright 1918). Cloth, 4x6 in., 427 pp. $0.50.

Tables showing production, prices, imports, exports, etc., of iron ore, coke, iron and steel products, copper, tin, lead, spelter, aluminum, antimony, silver and other metals. In most cases the statistics cover a number of years.

The Modern Gasoline Automobile. Its Design, Construction, Operation and Maintenance. A Practical, Comprehensive Treatise Explaining All Principles Pertaining to Gasoline Automobiles and Their Component Parts. By Victor W. Pagé. Revised and enlarged. The Norman W. Henley Publishing Co., New York, 1918. Cloth, 6x9 in., 1032 pp., 1000 illus., 11 charts. $3.

This edition has been brought up to date by careful revision and the introduction of supplementary matter on ignition, tractors, power transmission, carburetion, etc.

Sulphuric Acid Handbook. By Thomas J. Sullivan. First edition. McGraw-Hill Book Co., Inc., New York, 1918. Flexible cloth, 5x7 in., 239 pp., 35 illus., 87 tables. $2.50.

The author has collected in one volume of convenient size the chemical and mechanical data of practical value to makers and users of sulphuric acid in American industries.

Military Observation Balloons (Captive and Free). A Complete Treatise on Their Manufacture, Equipment, Inspection and Handling, with Special Instructions for the Training of a Field Balloon Company. By Emil J. Widner. D. Van Nostrand Co., New York, 1918. Flexible cloth, 5x8 in., 151 pp., 28 illus., 3 pl. $3.

This manual is based on the balloon manual of the German army, and the equipment and drill in use by the Germans at the beginning of the war. It gives a complete survey of the field.

Patenting and Promoting Inventions. By Mois H. Avram. Robert M. McBride & Co., New York, 1918. Cloth, 5x8 in., 166 pp. $1.50.

Written for the inexperienced inventor, this book gives sound, practical advice on the proper method of securing, protecting and promoting commercial patents.

Principles of Mechanism. By Walter H. James and M. C. Mackenzie. First edition. John Wiley & Sons, Inc., New York, 1918. Cloth, 5x8 in., 241 pp., 246 illus. $1.50.

Presents the elementary principles of mechanism without the use of advanced mathematics. Intended especially for trade schools, etc.

Principles of Ocean Transportation. By Emory R. Johnson and Grover G. Huebner. D. Appleton & Co., New York, 1918. Cloth, 6x9 in., 513 pp., 68 illus., 3 folded pl., 9 maps (two folded), 2 folded charts, 18 tables. $2.50.

A systematic, comprehensive review of the whole subject, including ocean couriers and their services, ocean conferences, ocean rates and fares, and the principles and practices of Government aid and regulation of ocean shipping. The book does not attempt to treat the various questions exhaustively but seeks to present the essential facts for students and business men.

Radiometric Apparatus. For Use in Psychological and Physiological Optics, Including a Discussion of the Various Types of Instruments That Have Been Used for Measuring Light Intensities. By C. E. Ferree and Gertrude Rand. Published as Psychological Monographs, No. 103. Paper, 7x10 in., 65 pp., 6 illus. $0.75.

After a discussion of various types of instruments that have been used for measuring light intensities, and the advantages and disadvantages of each, the authors describe the apparatus which they have found most desirable.

A Text-Book of Laying Off. The Geometry of Shipbuilding. By Edward L. Attwood and I. C. G. Cooper. Second edition. Longmans, Green & Co., London, 1918. Cloth, 6x9 in., 123 pp., 121 illus., 2 plates. $2.

This work is intended to provide students of naval architecture and ship draftsmen with a description of the processes and methods used in various shipbuilding yards and centers. The second edition has been revised with a view to greater clearness and some additions have been made to the text.

A Treatise on Roads and Pavements. By Ira Osborn Baker. Third edition, rewritten and enlarged. John Wiley & Sons, Inc., New York, 1918. Cloth, 6x9 in., 666 pp., 235 illus., 83 tables. $4.50.

Dr. Baker's work is a discussion of the engineering principles involved in the construction of country roads and city pavements, intended for the designer and inspector rather than for the contractor. Attention has been given to materials and forms of construction that affect the quality and cost of roadway rather than to methods of doing the work. This third edition has been thoroughly revised and entirely rewritten. Five chapters of minor importance have been dropped to make room for an equal number of new ones, and the number of illustrations have been greatly increased.

ACCESSIONS TO THE LIBRARY

BALDWIN LOCOMOTIVE WORKS. Problem of motive power under the National Administration of Railroads. Record No. 90. Gift of Baldwin Locomotive Works.

BANKING SERVICE FOR FOREIGN TRADE. *New York, 1918.* Gift of Guaranty Trust Co.

CARNEGIE FOUNDATION FOR THE ADVANCEMENT OF TEACHING. Annual Report of the President and of the Treasurer. 12th, 1917. Gift of Carnegie Foundation for the Advancement of Science.

CHEMICAL ABSTRACTS. Decennial Index, 1907-1916. Authors L-Z. *Easton, 1916.* Purchase.

CLASSIFICATION FOR PYROMETRY AND PYROMETERS. By A. O. Ashman and K. C. Walker. *April, 1918.* Gift of K. C. Walker.

COAL PROBLEM. By E. G. Bailey. Reprinted from the J. E. Aldred Lectures on Engineering Practice, 1917-18. *Baltimore, 1918.* Gift of Bailey Meter Co.

COMMUNITY HOMES. A booklet issued for the purpose of assisting those who are giving consideration to a much discussed question, industrial homes. *Cleveland, 1918.* Gift of The Hydraulic Pressed Steel Co.

CONCRETE FOR INDUSTRIAL HOUSING. *Chicago, 1918.* Gift of Portland Cement Association.

COSNA-NOWITNA REGION, ALASKA. (U. S. Geological Survey. Bulletin No. 667.) *Washington, 1918.* Purchase.

EFFECT OF ALKALI TREATMENT ON COCAS. (U. S. Dept. of Agriculture. Bulletin No. 666.) *Washington, 1918.* Purchase.

EL CUERPO DE INGENIEROS DE MINAS Y AGUAS. 1917. Gift of Cuerpo de Ingenieros de Minas y Aguas.

ELECTRON THEORY OF MATTER. By O. W. Richardson. *Cambridge, 1914.* Purchase.

EXPLOSIVES. Edition 2, vols. 1-2. *Philadelphia, 1917.* Purchase.

FEDERAL VALUATION OF THE RAILROADS IN THE UNITED STATES. Hearings Kansas City Southern Railway. April 15, 1918. (President's Conference Committee.) Gift of Clemens Herschel.

FINDING AND STOPPING WASTE IN MODERN BOILER ROOMS. Vol. II. *Philadelphia, 1918.* Gift of Harrison Safety Boiler Works.

FREEDOM OF THE SEAS. (Champion Monographs, April 3, 1918.) *New York, 1918.* Gift of The Champion Coated Paper Co.

FRENCH MEDICAL VOCABULARY. Compiled by Joseph Marie. *Philadelphia, n. d.* Gift of P. Blakiston's Son & Co.

GRAIN-DUST EXPLOSIONS. Investigation in the experimental attrition mill at the Pennsylvania State College. (U. S. Dept. of Agriculture, Bulletin No. 681.) *Washington, 1918.* Purchase.

GRAPHITE, 1917. *Jersey City, 1917.* Gift of Joseph Dixon Crucible Co.

IRON ORE OCCURRENCES IN CANADA. Vol. II, with maps. *Ottawa, 1917.* Purchase.

THE LAKE CLARK-CENTRAL KUSKOKWIM REGION, ALASKA. (U. S. Geological Survey. Bulletin No. 655.) *Washington, 1917.* Purchase.

LAYING THE RAILS FOR FUTURE BUSINESS. With a synopsis of the law for the Federal control of railroads. *New York, 1918.* Gift of Guaranty Trust Co.

LIST OF FERTILIZER AND LIME MANUFACTURERS AND IMPORTERS IN PENNSYLVANIA. (Bulletin No. 305, Penn. Dept. of Agriculture.) *Harrisburg, 1918.* Purchase.

THE LOCOMOTIVE. Vol. XXXI. *Hartford, 1916-17.* Gift of Hartford Steam Boiler Inspection and Insurance Co.

MARINERS AND MERCHANTS OF THE NORTH. Plans of Norway and Sweden to meet conditions after the war. *New York, 1918.* Gift of Guaranty Trust Co.

METAL MINE ACCIDENTS IN THE UNITED STATES DURING CALENDAR YEAR 1916. (U. S. Bureau of Mines. Technical Paper No. 202.) *Washington, 1918.* Purchase.

MINERAL PRODUCTION OF CANADA, PRELIMINARY REPORT. 1917. *Ottawa, 1918.* Purchase.

MINERAL RESOURCES OF MICHIGAN WITH STATISTICAL TABLES OF PRODUCTION AND VALUE OF MINERAL PRODUCTS FOR 1916 AND PRIOR YEARS. (Publication 24, Geological Series No. 20). *Lansing, 1917.* Purchase.

MINERAL RESOURCES OF THE PHILIPPINE ISLANDS, 1916. *Manila, 1917.* Purchase.

MINING AND QUARRY INDUSTRY OF NEW YORK STATE. *Albany, 1918.* Gift of N. Y. State Museum.

MONEY VALUE OF EDUCATION. (U. S. Dept. of Education. Bulletin No. 22.) *Washington, 1917.* Gift of Bureau of Education.

NEW INTERNATIONAL YEAR BOOK, 1917. Dodd, Mead & Co. *New York, 1918.* Purchase.

OIL AND GAS FIELDS OF THE UNITED STATES. Two-sheet wall map of U. S. corrected to March, 1917. Purchase.

OIL AND GAS POSSIBILITIES IN THE BELTON AREA. (Missouri Bureau of Geology and Mines.) *Rolla, 1918.* Purchase.

OIL AND GAS RESOURCES OF KANSAS. (Kansas State Geological Survey. Bulletin No. 3.) *Lawrence, 1917.* Purchase.

OPERATION OF PURIFICATION PLANTS, INSPECTION OF RESERVOIRS, AND THE LABORATORY CONTROL OF THE WATER SUPPLY IN THE CANAL ZONE, FISCAL YEAR ENDED JUNE 30, 1917. Report prepared by Geo. C. Bunker. Gift of *Engineering News-Record.*

PERU. Estadistica Minera en 1916. (Cuerpo de Ingenieros de Minas del Peru, Boletin No. 86.) *Lima, 1918.*

PRODUCTION OF CEMENT, LIME, CLAY PRODUCTS, STONE, AND OTHER STRUCTURAL MATERIALS IN CANADA. 1916. (Mines Branch No. 470.) *Ottawa, 1917.* Purchase.

RADIO COMMUNICATION LAWS OF THE UNITED STATES AND THE INTERNATIONAL RADIO-TELEGRAPHIC CONVENTION. Regulations governing radio operators and the use of radio apparatus on ships and on land. July 27, 1914. *Washington, 1914.* Gift of U. S. Naval Radio Service.

REINFORCED CONCRETE CONSTRUCTION. By M. T. Cantell. *London, 1912.* Gift of author.

RELATIVE RESISTANCE OF VARIOUS HARDWOODS TO INJECTION WITH CREOSOTE. (U. S. Dept. of Agriculture. Bulletin No. 606.) *Washington, 1918.* Purchase.

REVISION OF THE STRUCTURAL CLASSIFICATION OF PETROLEUM AND NATURAL GAS FIELDS. By Frederick G. Clapp. (Reprinted from the Bulletin of the Geological Society of America, v. 28, pp. 553-602, 1917.) Gift of F. G. Clapp.

UNITS OF WEIGHT AND MEASURE, DEFINITIONS AND TABLES OF EQUIVALENTS. (U. S. Bureau of Standards, Circular No. 47.) *Washington, 1917.* Gift of J. Kaiser.

U. S. WAR DEPARTMENT. Report of the Provost Marshal General to the Secretary of War on the first draft under the selective service act, 1917. *Washington, 1918.* Gift of War Department.

VALUE OF PEAT FUEL FOR THE GENERATION OF STEAM. (Canada. Dept. of Mines. Bulletin No. 17.) *Ottawa, 1917.* Purchase.

TRADE CATALOGUES

AMERICAN WHALEY ENGINE CO. Boston, Mass. Illustrated booklet.

CENTRAL FOUNDRY CO. New York, N. Y. Catalogue U-B. Universal cast-iron pipe and specials. 1912. Illustrated booklets describing cast-iron pipe.

ELECTRIC MACHINERY CO. Minneapolis, Minn. Bulletin No. 183. Lower pumping costs with E-M synchronous motors.

GENERAL ELECTRIC CO. Schenectady, N. Y. CR 3100 Drum-type controllers for series, shunt- or compound-wound motors.

B. F. GOODRICH RUBBER CO. Akron, O. Motor Trucks of America. Vol. 6, 1918.

LUDLUM STEEL CO. Watervliet, N. Y. Descriptive booklet of company. 1918.

MERCHANT & EVANS COMPANY. Philadelphia, Pa. Evans "Almetl" fire doors and shutters and the famous "Star" Ventilators. Illustrated booklet.

PETTINGELL-ANDREWS CO. Boston, Mass. Descriptive pamphlet "Four-in-one Light."

ROSS HEATER & MANUFACTURING CO. Buffalo, N. Y. Illustrations of Ross crosshead-guided expansion joints; surface condensers; multi-head water heaters, etc.

STANDARD PLUNGER ELEVATOR CO. Worcester, Mass. Standard Plunger Elevators.

In Two Parts—Part Two

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THE ECONOMICAL USE OF FUEL

A Symposium Contributed to the
Worcester Meeting, June, 1918

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
29 West 39th Street, New York

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TOPICAL INDEX

THE ECONOMICAL USE OF FUEL

At the Spring Meeting of The American Society of Mechanical Engineers, held at Worcester, Mass., June 4-7, 1918, sessions were held for the discussion of the all-important subject of fuel economy. In preparation for this session the Committee on Meetings invited the Fuel Conservation Committee of the Engineering Council to formulate a set of questions which was sent out to a list of fuel engineers throughout the country, and over 60 of whom responded with contributions.

The country now faces a coal shortage of 80,000,000 tons this year. We need 100,000,000 tons more this year than last, or 220,000,000 tons more than ever before mined in one year. Military draft has taken about 35,000 miners and there is a serious shortage of open-top equipment to haul coal. Every fuel user must exert his greatest effort to effect fuel economy and every engineer owes it as a public duty to render his utmost assistance to this end. In no small measure the symposium which follows should help in the conservation movement.

CONTRIBUTED DISCUSSION

On this and the following pages are published selections from the discussions received in response to the questionnaire issued for the Fuel Session of the Spring Meeting. These are grouped under the several headings to which the subject matter applies. In preparing the material for publication duplicate matter was eliminated so far as possible, and the whole is printed in concise form, so that it may be used for reference purposes with the greatest possible facility.

The topics upon which discussion was solicited are as follows:

1 **What Are the Economic Effects of Impurities in Coal?**

2 **To What Extent Is Fuel Oil Likely to be Used as a Substitute for Coal?**

3 **How Can Soft Coal Be Burned Without Smoke in Marine Boilers?**

4 **What Are the Possibilities in the Direction of the Utilization of Anthracite Wastes?**

5 **What Instruments Are Useful and Desirable in the Boiler Room as Aids in Saving Coal?**

6 **What Is Essential to the Economical Operation of Hand-Fired Boiler Furnaces When Using Soft Coal?**

7 **To What Kinds of Plants and Coals are the Different Types of Mechanical Stokers Respectively Adapted, and What Is the Limiting Factor to Their Use in the Small Plant?**

8 **What Experience Have You Had in the Use of Wood as Fuel? To What Extent Is Wood Available as a Fuel?**

9 **What Coal Economies Can Be Effected in Residence Heating?**

10 **What Coal Economies Can Be Effected in the Small Steam Plants?**

11 **What Experiences Have You Had With the Storage of Coal?**

12 **(a) To What Extent and Where Will the Gas Producer be Used to Produce Economies?**

12 **(b) To What Extent is Natural Gas Being Used as a Fuel for Power Purposes?**

12 **(c) What is the Relative Economy of the Locomotive of 1900 and Today?**

12 **(d) What Proportion of the Coke is Made in By-product Ovens?**

12 **(e) What are New and Important Developments in Methods of Burning Coal?**

12 **(f) What Economies have Resulted from Recent Practice in Making Brick Settings Leakless?**

12 **(h) Is Automatic Air Supply Correctly Proportioned to Coal Supply Possible?**

12 **(i) Miscellaneous—School Heating—Insulation—Smoke Prevention.**

Preceding the contributions on the specific topics of the questionnaire, are three discussions of an introductory character which were presented at the meeting by their authors. The first, by David Moffat Myers, Advisory Engineer of the Fuel Administration, outlines the work of fuel conservation which is being undertaken by the Government; the second, by E. L. Cole, of the Fuel Administration of Pennsylvania, tells of the effective work in that state, the source of our anthracite supply, to secure clean coal; and the third discussion, by Alfred C. Bedford, President of the Standard Oil Company, deals with the supply of fuel oil.

In presenting his discussion, Mr. Cole interspersed his remarks with definite statements regarding operators and dealers who had been penalized for delivering inferior coal, and left the impression strongly in the minds of his audience that the Pennsylvania Fuel Administration had the question of a proper quality for the anthracite supply well under control. Following his remarks resolutions were passed, given on page 616, in which those present warmly pledged their support to the Pennsylvania Administrator and heartily approved his accomplishments.

THE GOVERNMENT'S PLAN FOR FUEL CONSERVATION

By DAVID MOFFAT MYERS[1]

As a member both of The American Society of Mechanical Engineers and of the United States Fuel Administration, it gives me pleasure to report the positive and progressive measures which have been taken by the Government for effecting fuel conservation in power plants and on railroads since the last annual meeting of this Society, in December, 1917. At that meeting, in my paper on Preventable Waste of Coal in the United States, a saving of 50 to 100 million tons per year was shown to be possible, together with suggestions as to measures for effecting this economy. I am not overstepping the mark when I state that the national program which I will outline to you, was planned, presented and organized by members and committees of the national engineering societies.

As a result, a Fuel Engineering Division was formed in the United States Fuel Administration in Washington, under its Bureau of Conservation. This division comprised two depart-

[1] Advisory Engineer of the U. S. Fuel Administration. Mem. Am. Soc. M. E.

ments—Railroads and Industries; the latter covering all power plants not belonging to railroads. The railway department was placed in charge of one of the highest authorities in this field in the country, Major Edward C. Schmidt, U. S. R., Mem.Am.Soc.M.E., who was transferred by Secretary Baker to the U. S. Fuel Administration. Major Schmidt devised and developed a plan of organization which was the work of a master mind. It was authorized by the Fuel Administration and endorsed by Mr. McAdoo's special representative. The Railway Administration determined to administer the program through its own organization, whereupon Major Schmidt was given over to the other administration, for the continuance of the work.

At present, therefore, the Fuel Engineering Division devotes itself exclusively to the work of conservation of fuel in stationary power plants, and in the efficient use of steam after its generation. The organization comprises the central office at Washington, with an administrative engineer appointed (or to be appointed) in each coal-using state, attached to the Federal Fuel Administration of that state. The Administrative Engineer has a consulting board of competent engineers, and a staff of technical and clerical assistants and inspectors.

The plan of organization involves centralization on essential fundamentals only. These are uniform for all states. All other features are localized and extremely elastic in their numerous ramifications. This adopted principle renders the plan workable and effective under widely varying local conditions and circumstances.

The fundamentals of the national program are as follows:

a Personal inspection of every power plant

b Rating and classification of every power plant in the country, in five classes, depending upon the thoroughness with which the owner conforms to the recommendations of the U. S. Fuel Administration

c At the discretion of the Federal Fuel Administration, the supply of coal to any needlessly wasteful plant may be curtailed or stopped.

The plan is now in operation in Pennsylvania, the largest coal-consuming state, and also in Connecticut. Other states which have come in but in which the Administrative Engineer is not yet appointed, are Massachusetts, New York, New Jersey, Illinois, Michigan, Wisconsin, Indiana and Missouri.

For the office of Administrative Engineer, men are required of great organizing and administrative ability. For New York State, Mr. Edward N. Trump, Mem.Am.Soc.M.E. and vice-president of the Solvay Process Company, has patriotically accepted the nomination. Mr. Thomas R. Brown, the first Administrative Engineer actually appointed, is in charge of the western district of Pennsylvania. The second appointment was that of Mr. W. R. C. Corson for Connecticut, an officer of the Hartford Steam Boiler Insurance Company.

The standard recommendations of the United States Fuel Administration are substantially as follows:

a *Fuel.* That means be provided for measuring and recording fuel used each shift or day

b *Water.* That boiler feedwater be heated by exhaust steam or waste heat, and measured

c *Air Supply.* That a correct amount of air be supplied to the fuel, and that proper means be provided for measuring and regulating the draft

d *Clean Heating Surfaces.* That boiler heating surfaces be kept clean inside and out

e *Boiler and Furnace Settings.* That the furnace and setting be kept in good repair, and free from air leakage

f *Insulation.* That exposed steam surfaces wasting heat by radiation be covered with suitable insulating material

g *Engine-Room and Heating System.* That wherever possible, exhaust steam be utilized to the exclusion of direct steam from the boilers. (The plant should be designed and operated to produce no more exhaust than can be efficiently utilized in heating and process work)

h *Supervision.* (1) That a competent employee or committee be detailed to supervise the work of fuel conservation in the boiler and engine plants; and (2) that a competent committee be appointed in charge of the work of fuel conservation in the buildings and shops outside of the power plants.

To assist in this work, the United States Fuel Administration has prepared a fifty-minute film of moving pictures, showing good and bad operation in the steam-boiler plant, methods of testing boilers, fuels, etc. These pictures will be available to each state, in connection with their publicity and educational propaganda.

The Fuel Administration is also preparing a series of official bulletins on engineering phases of steam and fuel economics. Some of these are now in press.

They will include: Boiler and Furnace Testing; Flue-Gas Analysis; Saving Steam in Heating Systems; Boiler-Room Accounting Systems; Saving Steam and Fuel in Industrial Plants; Burning Fine Sizes of Anthracite; Boiler-Water Treatment; Oil Burning; and Stoker Operation.

In addition to this service, a list of competent engineers has been prepared in Washington for each state, and is available for use of the local administration. As the work develops, still further constructive assistance is contemplated for helping owners to bring their plants up to a high plane of economy.

LIMITING COAL IMPURITIES IN PENNSYLVANIA

BY E. L. COLE[1]

Prior to the world war the capacity of the bituminous and anthracite mines in the United States to produce fuel was so much in excess of the demand that competition was an ample and certain factor in assuring the marketing of coal containing only a minimum of impurities.

With the steadily increasing demand for fuel, caused by the rapid development of war industries, there was a noticeable increase of the amount of impurities in anthracite and bituminous during the winter months of 1917.

These facts were known to the Fuel Administration, but because of the clamor among consumers, domestic and industrial, which was accentuated by weather conditions, for any sort of coal, action was deferred at that time. However, friendly suggestions were made to operators in the hope that the quality of coal would show improvement.

It was a vain hope.

During the Arctic-like weather of the second half of last winter the demand for coal skyrocketed to a point never before reached in this country. At the same time, the quality decreased with amazing rapidity, aggravating the existing fuel famine to a degree not readily credible.

The tonnage of inferior coal that was delivered in January was so large as to cause the Fuel Administration to take action. Dr. Garfield, National Fuel Administrator, assigned Mr. James Neale, of his staff, to assist the Pennsylvania Administration in providing and applying remedial measures in the anthracite fields.

[1] Secretary Conservation Division, Federal Fuel Administration for Pennsylvania.

Mr. Neale conferred with Mr. William Potter, State Fuel Administrator for Pennsylvania. With the aid of three gentlemen, who are the Fuel Chairmen in Luzerne, Lackawanna and Schuylkill Counties (Messrs. Tudor R. Williams, A. C. Campbell and Baird Halberstadt), an investigation was carried on into the amount of impurities being shipped to market.

The Fuel Administration then formulated rulings limiting the percentage of slate, bone and under sizes that would be permitted by the Government in all sizes of anthracite. Inspectors were appointed in the three counties mentioned with authority to condemn all coal found below standard. The writer was directed to supervise the inspection of coal at destination points within the State.

Effectiveness of Inspection and Penalties Imposed

The effectiveness of the inspection at the mines and destination points may be indicated by the report for May. These show that less than one-half of one per cent of the daily anthracite production of more than a quarter million tons was condemned by the Federal Inspectors for the month of May. This coal was condemned at the mines, and reprepared for delivery. The vast improvement can be better visualized when it is recalled that more than 50 per cent of the marketed tonnage during January and February contained excessive amounts of impurities.

During the inspection at destination, a car of buckwheat, containing 45 per cent of impurities, was delivered at a textile mill in Philadelphia. The fireman was unable to keep steam above 55 lb., normal steam pressure being 80 lb. Production at the mill fell off 30 per cent and the cost of removing ashes increased 300 per cent. The coal company was compelled to rebate to the mill owner 50 per cent of the cost of the coal, together with an equal percentage of the freight and cartage costs.

Operators who deliver coal containing excessive amounts of impurities have been subjected to various penalties. Some cars were ordered hauled to the dumping grounds in Philadelphia; others were donated to hospitals and other non-profit-making institutions. A few cars were delivered to churches. Many cars enroute to market were diverted back to the mines. In all cases the producing companies were compelled to pay the freight and other charges, and donate the coal. This action by the State Fuel Administrator had a tremendous moral effect upon the producers, and strengthened the arms of the Federal Inspectors at the mines, because publicity was given each case.

Many bituminous as well as anthracite operations have been closed because of the inferior coal shipped from them.

It is the observation of the Fuel Administration that steam sizes of anthracite containing 40 per cent of impurities are so inefficient in generating steam that the cost of such fuel is commercially prohibitory.

Allowable Limits for Impurities

Steam size of anthracite containing not more than 20 per cent aggregate impurities enable firemen to maintain maximum steam under the most difficult conditions. When the amount of impurities exceeds 20 per cent, there is at once a noticeably increased amount of fuel required to maintain normal steam pressure. In addition to this, there is an increase of 10 per cent in the cost of fuel when the percentage of impurities is increased from 20 to 25 per cent, and a further increased cost in the removal of ashes.

However, expert firemen obtain fairly good results with anthracite steam sizes containing as high as 30 per cent of slate and bone, but the fuel costs show an increase of 25 to 37 per cent above the cost of the same size fuel containing only 15 per cent of impurities.

Any steam anthracite containing more than 30 per cent of slate or bone is too expensive for the manufacturer to purchase today, according to our observation. All steam coal containing more than 20 per cent of impurities is condemned when it comes under the observation of the Fuel Administration. This is so even when it is found at destination points in Pennsylvania.

Impurities in Domestic Sizes of Anthracite

The effect of increase in impurities in domestic sizes of anthracite is much more marked than in steam sizes. The domestic sizes include pea, nut, stove, egg and broken coal.

Excellent results are obtained with pea coal containing 8 to 10 per cent of slate and the same amount of bone. That is a total of 16 lb. of impurities in 100 lb. of coal.

When the amount is 11 to 12½ per cent of slate, satisfactory results are obtained but ashes must be removed at more frequent intervals, and more attention given to the fire. At the same time, there is an increase of at least 5 to 8 per cent in the cost of fuel. This applies equally to this size of coal in use of low-pressure and high-pressure service.

Pea coal containing 20 per cent of slate is worthless for low-pressure boilers. In high-pressure practice, fairly good service can be obtained, but ashes must be removed at more frequent intervals and more attention be given to the fire. At the same time, there is an increase of at least 5 to 8 per cent in the cost of fuel.

In high-pressure practice, fairly good service can be obtained with 25 per cent of slate, but the cost of such fuel is virtually prohibitory. The larger the size of anthracite, the lower must be the percentage of impurities to obtain maximum service. No shipments of pea coal with more than 12 per cent of slate are permissible.

Chestnut gives best results when impurities do not exceed 5 per cent of slate and an equal percentage of bone (bone contains 50 per cent of carbon). Any increase above this figure is marked by inferior service. At 15 per cent fires must be carefully attended, or it will be necessary to relight them twice within 24 hours. Chestnut coal containing 20 per cent of slate is so inferior that any price for such fuel is exorbitant. All nut coal containing 7 per cent of slate is condemned by the Fuel Administration.

Stove coal containing 5 per cent of slate and 6 per cent of bone gives maximum service. At 6 per cent of slate and 7 per cent of bone, the result is increase of 8 per cent in fuel costs. This size coal containing 8 per cent of slate and 9 per cent of bone shows the maximum possible amount of impurities that can be used by domestic consumers, discounting the high cost of such fuel. Any percentage above this renders the fuel worthless.

Egg coal should not be used when the amount of slate is more than 4 per cent and 5 per cent of bone. This size of coal is difficult to burn unless it is virtually free from slate. Our standard permits 2 per cent of slate and the same of bone, and because of the size of this coal (it is the size of an average fist) the slate can be readily removed by the consumer. It is much better to do so than to obtain inferior results by shoveling the dirty coal into the furnace. It may be stated that the amount of slate allowed in this coal is only equal to one piece of slate in 100 lb., and two pieces of bone in the same weight.

Broken anthracite must be virtually free from slate or bone. Even in foundry practice, as well as domestic service, it is necessary to remove all slate from this coal before it can be

used. It can be readily perceived that this is imperative when the inspection schedule only allows 1 per cent slate and 2 per cent of bone. This is less than the weight of a piece of bone or slate of this size of fuel. During January many cars of broken anthracite were shipped from the mines into Philadelphia, containing from 12 to 25 per cent of slate.

Imperative Need of Schedules for Limiting Impurities

There is a serious lack of authoritative data on the subject of schedules for impurities. It can be stated without question that bituminous containing more than 2 per cent of sulphur should not be used for locomotive purposes. Two and one-half per cent is the maximum that most standard railroads accept. More than 8 per cent of slate and other impurities makes the coal dear at any price. It is expected that rulings standardizing the quality of bituminous will be issued at an early date.

The essential need of authoritative data on the subject of impurities is emphasized by the attitude of some producers. Last Monday, the president of one of the largest anthracite-producing companies urged that the percentage of impurities in anthracite be increased 2 per cent above the existing standard.

When told that this will result in delivering annually to consumers, at least 1,500,000 additional tons of slate and dirt, at the highest prices ever obtained in the markets, one will readily agree that it is imperative that incontrovertible data should be at hand to sustain and make permanent the present standards governing anthracite deliveries.

To haul the proposed 2 per cent increased allowance of impurities would require about 40,000 railroad cars for a period extending from two to ten weeks, in 50 trains of 80 cars, each pulled by an equal number of locomotives, employing the necessary train crews.

The benefit of delivering one and a half million tons of slate and dirt would result in adding to the profits of producers to the extent of at least six million dollars!

The plea for this proposed allowance was based entirely upon the decreasing labor supply and the increasing needs for anthracite, but, as shown, to permit additional impurities would really increase the volume of fuel production but decrease the value of fuel delivered to consumption points. The Fuel Administration for Pennsylvania is giving serious consideration to some other method of increasing production without increasing the amount of impurities permitted in coal.

Any honest suggestion for increasing anthracite production by lowering the standard of preparation should be accompanied with an offer to reduce the market price in exact ratio to the decreased fuel value of the product.

What the Society Can Do

At this point it may be well to offer the suggestion that this Society take up the task of obtaining data on the commercial cost of impurities of fuel. Recommendations should then be formulated by this Society to the Fuel Administration, that may crystallize into legislative enactment that will make it a crime for unscrupulous producers to unload on consumers inferior product, in much the same way as manufacturers of food are prohibited from delivering to our tables product unfit for human consumption.

The mining and transportation of coal requires a vast army of workers. The quality affects every person in this great country. Is it not a question worthy of the most serious consideration that men of science can give it?

To this end, the writer is authorized to say that William Potter, Federal Fuel Administrator for Pennsylvania, pledges himself and his Administration to aid any measure undertaken to insure to consumers, industrial and domestic, reasonably clean coal as a permanent institution in the United States.

Because the anthracite production is confined to Pennsylvania, the responsibility for overseeing the quality of production rests largely on the shoulders of State Administrator Potter. And it is his task to see that the vast tonnage, reaching almost to 80 million tons, from the Pennsylvania mines shall be of a quality that will enable our manufacturers to produce the essential commodities of life with a minimum amount of waste, at the prices fixed by the Government.

The Administrator invites the patriotic support of this Society in his task of keeping the quality of coal delivered to our hearthstones at a high standard, so that the home fires in the United States may be kept burning brightly while we wait the return of the "boys" who have crossed the sea to battle with the Hun that man may work out his destiny free from the shackles of despotism.

THE FUEL-OIL SITUATION

By ALFRED C. BEDFORD[1]

The opportunity presented to me as Chairman of the National Petroleum War Service Committee to appear before you is one which I welcome and appreciate most heartily. But if you have been looking to the Petroleum Committee for an easy and quick solution of your fuel problems by the proffer of all the fuel oil you want to take the place of coal and other fuels, I am afraid I am due to disappoint you. I am here rather to plead for special economy in the use of fuel oil and for its use only where, from the nature of the work, you cannot properly use coal.

Do not think me an alarmist. I am not trying to warn you of any petroleum or fuel oil famine. But we are all one in our wish to help win the war, and, with that end in view, we want to adjust our available resources and supplies as effectively as we possibly can to the needs of the war.

What are these needs in regard to fuel oil? First and foremost is the Navy, and in the Navy for the war purposes which we are now considering, I include oil-burning cargo ships and transports, as well as the battleships, destroyers and submarine chasers.

Fuel oil is hardly less important for our ocean-going steamships, where one of its great values lies in the saving of space and weight, making possible the carrying of much larger cargoes than where room otherwise is given up to bulky coal supplies.

Our shipyards are rapidly reaching the point where large numbers of vessels will be launched. Careful computation shows that three oil-burning ships of a given tonnage of, say, 6000 tons each, will yield the same efficiency as four ships burning coal of a like tonnage. The tremendous importance of this fact of efficiency is shown when one realizes that three hundred oil-burning ships will carry the same cargo as four hundred coal-burning ships of the same size.

Meantime, the needs of our Allies have to be met, and exports of fuel oil have been for many months, and may be expected still to continue, on an ascending scale. When you add to these the requirements of the essential war industries for tempering, annealing, and other processes, for which coal is less suitable, you will realize the tremendous volume of the demand which simply has to be met.

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[1] President, Standard Oil Company.

In 1917 our consumption was in excess of our production and importations of crude oil from Mexico, and it is fair to assume an increased consumption in 1918. Our production does not at present measure up very well to these anticipated demands, but, realizing the situation, oil operators everywhere are keen to develop it with all possible dispatch.

While fully cognizant of the important needs of fuel oil as related to the manufacturing industries, the point must be emphasized that it is impossible to take oil for any one specific purpose without exerting a detrimental influence on some other branch of industry. A very large volume of oil is being used today in the manufacture of gas, and much gasoline is obtained from what would otherwise be fuel oil. The demands for gasoline, however, are such that I must again earnestly urge upon every consumer the imperative necessity of conservation. Indeed, it may become necessary to enact definite and drastic regulations to restrict its needless consumption.

The oil men have organized so as to render the most efficient service, first, in supplying the full needs of the Government and the Allies, and second, in taking care of the ordinary business condition of the country along the lines of priority as laid down by the Fuel Administration.

What then are the conditions governing the present supplies of fuel oil?

So far as the Atlantic Coast is concerned, transportation is at the root of all of our troubles. While hundreds of thousands of barrels of petroleum are available in Mexico, and thousands more might be shipped from the Gulf ports, there is no way of getting these supplies North in the quantities needed. There is a shortage of shipping and the Government has found it necessary to requisition a large percentage of all the tankers in service. The pipe lines are running to capacity, and railroad conditions make it impossible to obtain any material relief by the use of tank cars. We are therefore face to face then with the necessity of making the available supplies of fuel oil along the Atlantic Coast cover the present ever-increasing essential demands. Coal can be obtained. The output of coal can be increased. But the supplies of fuel oil here at present cannot.

The consequence is we must ask the factories here in the East to burn less fuel oil, or none at all where it is possible to burn coal without interfering with the efficiency of the processes involved. Particularly, fuel oil should not be used under steam boilers, either stationary or locomotive. For metallurgical work in small forges and in large forge furnaces, and those used for annealing, etc., oil has its legitimate and essential place, though even here I would urge all the economy possible. But the ordinary user of heat apparatus for the production of steam power will do well to consider coal as his best source of supply, and disregard for the time being the possible advantages of oil.

Considerable difficulties were experienced in many quarters last winter, owing to the limited oil storage provided by consumers and to the irregular running of tank cars. I would therefore urge oil users to plan at once to increase their storage capacity to at least 60 days' supply, and to see that this storage, when completed, is kept full.

1 What Are the Economic Effects of Impurities in Coal?

Incombustible in fuel has a detrimental effect upon furnace operation out of all proportion to the percentage of refuse contained. It has been claimed that when coal contains 40 per cent of refuse it becomes valueless as fuel. Recent conditions have afforded opportunities for interesting observations in this connection. What has been your experience?

W. S. GOULD.[1] During the last two years, as prices have mounted higher, the quality of the fuel shipped to market has decreased until lately the lack of quality of the so-called coal available to the power plants of the country has become a decided menace not only to our economic development but to the safety of the nation. It is incumbent upon every one to become familiar with the dangers of the situation and to use whatever influence he may have to force an immediate change in this aspect of industrial activity.

It makes no difference how much our railroad equipment is increased, it makes no difference what prices are fixed by the Government for coal, nor how many rules and regulations are issued by the Fuel Administrator, so long as drastic and effective steps are not taken to insure the proper preparation of the coal mined and shipped.

Efficiency Loss from Ash

The Bureau of Mines estimated that the ash of coal mined in 1917 had increased 5 per cent for the whole country, and that this increase in the ash content meant a further loss of 7.5 per cent in the efficiency of the power plants. Some of the mining districts show a much higher increase in this one element in coal. However, taking the Bureau of Mines estimate, this means in figures of tonnage, that while we produced and shipped 544,000,000 tons of fuel in 1917, the tonnage was equal in effective power-producing qualities to only 476,000,000 tons of the 1916 quality. In other words, in 1917 we mined and shipped about 41,000,000 tons more of material than in 1916 to do 27,000,000 tons less work. Assuming that the work done by the 544,000,000 tons of poor coal was all we had to do, we mined and shipped some 70,000,000 tons simply to make up for the inferior quality. This is the real cause of our coal troubles.

Shipment of Weathered Coal

This, however, is not the whole story. While the increase in the ash content was fully equal to 5 per cent, the decrease in the heat was considerably greater than 5 per cent, this decrease being due to the fact that millions of tons of weathered coal were shipped—pillar and outcrop coal and refuse from mine dumps—all of which was considerably lower in heat in proportion to the ash content than would have been the case if the coal had been freshly mined from the seam. The Fuel Administration originally encouraged these "wagon mines," the number of which increased enormously, directly cutting down the available fuel.

Influence of Sulphur on Clinker

In addition to the well-established loss in efficiency and capacity of our power plants, due to the higher percentage of the ash impurity, we should not lose sight of the further loss in efficiency and capacity due to the increase in the sulphur

[1] President, Fuel Engineering Company of New York, New York. Assoc.Am.Soc.M.E.

content of coal. Sulphur in coal affects the economy of the boilers by forming clinkers, which hinder the proper distribution of air. This improper distribution may be excess or deficiency of air.

It has been found that while the drop in the combined efficiency of the boiler and furnace averaged about 0.5 per cent for each per cent of sulphur between 0.5 and 6 per cent, the general drop in boiler capacity is about 1.5 per cent for each per cent of sulphur. The increased amount of clinker, due to the higher sulphur percentages, is doubtless responsible for this drop in the capacity, reducing the rate of combustion and therefore capacity. This loss is in addition to the losses estimated for increase in the ash impurity and the relatively greater loss in heat due to weathered coal.

Before 1916 eastern coals that carried sulphur in excess of 3 per cent were not common. Since that time the cases of 5 and 6 per cent sulphur, and some almost incredibly high, have steadily increased, until during the last winter it has been quite the exception to find coals with less than 2 per cent.

Then there is the damage that sulphur causes to the tubes, plates and grates of the equipment—a damage that is usually difficult to measure, especially since it is generally unexpected by the plant engineer, or comes when he has no time to make exact calculations or cannot get information as to his coal.

Just two examples of the many cases that have come under our own observation may be given:

a A plant equipped with Model stokers had been using a certain coal which did not average high in sulphur—about 1.60 per cent, but of a character that often causes trouble under similar conditions. The plant had been running wild, with a low rate of efficiency, and there had been no special trouble with the grate bars, which had stood up for weeks. Better operating methods were inaugurated, and the grate bars began melting at an alarming rate, some in about a week. Ordinarily, the cause of this trouble would have been laid either to the operating methods, and therefore a necessary evil, or to the grate bars. We selected, through our Library of Coal Records, a coal of equal heating value but without the characteristics of the coal being used at the plant, and the trouble with the grates ceased.

b Another case was in a plant with flat grates, hand-fired, and running at a low rate of combustion. This plant had been using a coal which was excellent so far as ash and heat were concerned, but which averaged about 2 per cent sulphur. The boilers not being forced, there had been no appreciable damage from the sulphur in the coal. A new lot of coal arriving, showing about 3.50 per cent sulphur, but otherwise being about as usual, I suggested that, with their operating conditions, they would probably find little trouble from clinkering, incidentally remarking that the only probable damage would be to their equipment. The superintendent asked if that were not more or less imagination, so I suggested his making a simple test of the point. One boiler was carefully cleaned and practically new grates installed. It was arranged that the 3.50 per cent coal should be used exclusively under this boiler for one day, and then the fires pulled and an estimate made of any damage that could be observed. A few days later we received a letter from the superintendent stating that the test was run as directed, and that "after four hours the grates were entirely destroyed."

Walter N. Polakov.[1] The value of coal as used for power production is chiefly determined by its steaming capacity. Generally, there are two reasons for the condemnation of steam coals:

a When the composition and peculiarities are unfit for *existing* equipment

b When impurities make it unfit for *any* equipment.

Coals that are unfit for existing equipment or requirements should not be purchased at all, as they may be used to advantage elsewhere. The opinions on the subject advanced by miners, dealers, purchasing agents and accountants should be submitted for final disposition to engineers who are guided by facts.

Coals with a high percentage of non-combustibles were used by the author last winter in both hand- and mechanically-stoked furnaces. For instance, a mixture of 1 part run of mine and 5 parts of anthracite screenings was observed to show never less than 60 per cent of boiler and furnace efficiency. This mixture contained:

Ice and water	15 per cent
Earthy matters	28 per cent
Oxygen	2 per cent
Total	45 per cent

Results from Impurities in Coal

From a large number of observations with coals contaminated with non-combustible impurities that are thrown on the market by some dealers at the risk of the country's liberty and honor, several conclusions may be drawn:

a While the efficiency of steam generation with so-called war coals drops from 10 to 25 per cent, the improved boiler-room management based on task work with bonus invariably more than offsets this loss. (Fig. 1.)

b The steaming capacity of coal drops along a parabolic curve; i. e., with the increase of ash content the evaporation drops more rapidly in the beginning and more slowly when ash percentage is getting high. (Fig. 2.)

c From Fig. 2 it appears that the increase of ash content from 14 to 18 per cent reduces the evaporation per pound of coal from 9 lb. to 8 lb. of steam (11.1 per cent), whereas further drop of evaporation from 8 to 7 lb. per pound of coal (12.5 per cent) corresponds with the increase of ash content from 18 per cent to 28 per cent.

It should be noted that these data are obtained from a number of hand-fired plants using mixtures of hard and soft coal for a period of over 18 months. The means of recording the performances were in all cases most rigorous, specialists taking continuous checks on accuracy, firemen trained and methods of firing constantly adjusted to secure the best possible results. While the deviations of results with each kind of coal are sometimes large, due to difference in plant equipment and degree of training of firemen, the tendency of retarded drop of efficiency with higher percentage of ash remains noticeable throughout.

d While extra cost of haulage and extra expense for the labor of handling coal and furnace refuse are easily estimated, the more important, though less noticeable, loss is due to difficulties connected with the admission of the proper amount of air into the furnace. If this is judged by the rate of firing (lb. per hr.), excess of air is inevitable with coals high in ash. Similarly, if direction is given by draft indications, extra resistance of fuel bed is liable to mislead the fireman. Again, if adjustments are based on gas analyses, the improper velocity of gases

[1] Consulting Engineer, 31 Nassau St., New York. Mem. Am.Soc.M.E.

through the boiler may lower the efficiency of heating surface for the sake of high furnace efficiency, ultimately at the expense of combined efficiency. Also, losses are incurred by more frequent cleaning of fires.

e By far the greatest economic effect of impure coals is the misuse of rail and water facilities for transporting the harmful, or, at best, useless, ingredients. The National

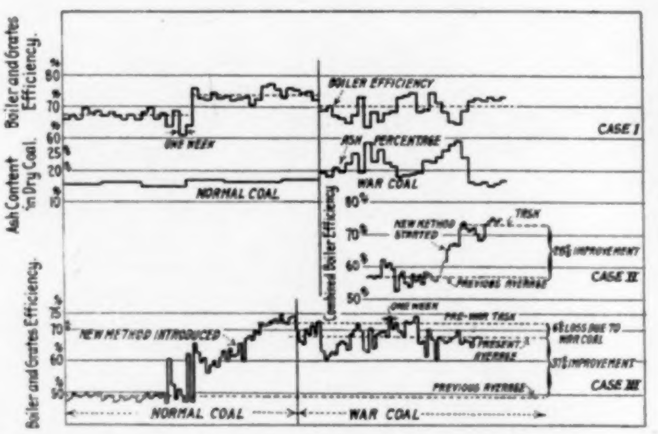

FIG. 1 EFFECT OF IMPURITIES IN COAL ON BOILER EFFICIENCY IN TYPICAL POWER PLANTS

Note: Task Work with Bonus more than offsets the harmful effect

Coal Association in a statement issued April 28, 1918, announces that "Interference with the war program is almost inevitable throughout the East, unless there is a readjustment soon of traffic over Eastern railroads." Decrease in production of coal because of car shortage is estimated by the same authority at about 20 per cent.

f Instead of thus harassing the Government in its task of operating railways and jeopardizing the country's production at this grave moment, the coal producers could disprove the charge of disloyalty by more careful preparation of coal at the mines. Cleaner coal will, as we have seen, not only release large parts of the rolling stock engaged in transporting dirt and slate, but also reduce the tonnage required for steam generation.

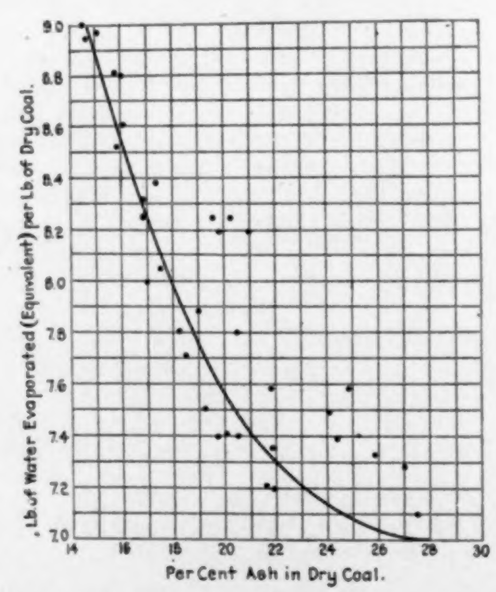

FIG. 2 RELATION BETWEEN ASH CONTENT AND EVAPORATION

g It is to be remembered, however, that half-measures toward preparation of cleaner coal at the mines will not go half way in ameliorating the present car shortage and furnace wastes. By reducing ash percentage from 28 to 21 per cent, only seven cars out of every 100 will be released, yet by removing also the other half of impurities from coal (*i. e.,* placing the quality of coal on pre-war standard) the need will be satisfied with 78 cars out of every 100 now tied up.

To sum up, the vicious economic effect of impurities in the war coal can be overcome as follows:

a A twenty per cent car shortage may be taken care of by releasing 22 per cent through reinstatement of previous quality of coal preparation.

b Further conservation of coal is possible by adopting more scientific methods of power generation and management of plants.

CARL J. FLETCHER.[1] During last winter much coal was wasted throughout Indiana due to the forced change in fuel. There are three very marked differences between the coal mined in Indiana and the coal mined in eastern Ohio, Pennsylvania and West Virginia: first, the amount and quality of the volatile matter; second, the liability to clinker; third, the form in which the impurities occur in the coal as delivered at the boiler room.

Regarding the volatile matter, the eastern coal is higher in hydrogen, making the volatile gases more easily combustible, also less in volume. The principal trouble in burning Indiana coal lies in lack of combustion space, which is necessary for the burning of very high-volatile coal, and a proper distance from the fuel bed to the comparatively cold boiler plates, which robs the furnace of heat and does not allow a sufficiently high temperature for the combustion of all the volatile matter.

Second, the clinkering of coal, when western coal has been substituted for eastern coal, is due primarily to the fact that there is more iron pyrites in Indiana coal. Iron pyrites can be successfully burned without objectionable clinkering under proper conditions. More draft is required to burn Indiana coal, both to keep the grates cool and to get a proper mixture of the volatile matter with oxygen. It often happens that in planning for a change to Indiana coal the grate surface is enlarged, reducing the available draft over the fire, when the proper procedure in this case would be to increase the force of draft.

Regarding the difference in the form of impurities in eastern and western coal, the impurities in Indiana coal appear mostly as shale, which cannot be burned; whereas, ash in the eastern coal is generally evenly distributed throughout the coal, and when eastern coal is burned it is a comparatively easy matter to free the fuel bed of ash. Shaking grates, such as are suitable for eastern coals, generally fail when applied to western coal. It does not do any particular harm to stir and mix some coals, while other fuel beds must not be disturbed. To burn Indiana coal it is necessary to have a type of grate with at least 50 per cent air space, and a grate which will crush the larger pieces of impurities and remove these impurities with a minimum disturbance of the burning fuel.

C. E. VAN BERGEN.[2] The value of coal producing 40 per cent ash depends, first, on the price of coal; second, on the expense of placing it on the grates; and third, upon the cost of removing the 40 per cent ash. We estimate that such a coal

[1] Fuel Engineer, Knox County Coal Operators' Association, Indianapolis, Ind.

[2] Vice-President and General Manager, Duluth (Minn.) Edison Electric Co.

will evaporate, under ordinary conditions, 3 lb. of water.

Our records show, that the coal we used from November 1, 1916, to March 1, 1917, evaporated 7.62 lb. water per lb. coal and contained 10 per cent ash. From November 1, 1917, to March 1, 1918, our coal contained 17 per cent ash and evaporated 6.69 lb. water per lb. coal. An increase of 7 per cent in ash content resulted in a loss in evaporation of 12.2 per cent.

W. L. Abbott.[1] In experiments made with a chain-grate stoker, using Illinois coal mixed with various percentages of ash, the capacity and efficiency of the unit dropped gradually with an increase of ash up to 35 per cent, after which they declined rapidly to zero efficiency and capacity with a fuel containing 40 per cent ash. The fuel would still burn, but the boiler would not generate steam. The fuel used in the test was made by mixing various amounts of ashes with a clean pea coal, the ash content of which was about 8 per cent. Thus, in the final test, the coal containing 8 per cent of ash was mixed with an additional 32 per cent of impurities. A different furnace or stoker might have given a somewhat different result, but it is questionable if any other form of stoker would have handled a fire containing that great amount of readily fusible ash.

Results obtained from this series of tests, which were made by mixing ash with the coal, correspond with results obtained by the Bureau of Mines in tests made in St. Louis using coals with an inherent ash content ranging up to 25 per cent, above which point the Bureau's tests did not go.

In a gas producer a fuel mixture of the kind first described would, no doubt, have given some useful results. A blast furnace always operates with a fuel mixture containing more than 40 per cent of non-combustible. If a coal contained as much as 40 per cent ash, it would not be marketable, and might rather be called a bituminous shale. Marketed coal contains between 2 per cent and 15 per cent ash, as extremes, but is usually below 10 per cent. If the fuel mixture carries more, it is due to impurities which are associated with the coal; for example, a coal seam analyzing 10 per cent in a seam sample may produce mine run containing 15 per cent ash.

With increasing ash content there is a decreasing boiler efficiency and an increasing cost of the steam produced, and while coal containing nearly 40 per cent of ash may produce some steam, it is rare indeed that it is economical to use coal containing as high as 20 per cent ash.

H. Kreisinger.[2] In the outline of this topic is a statement that when a fuel contains 40 per cent refuse the fuel becomes valueless. This statement cannot be applied generally as there are places where such fuel has economic value. In power plants located near the mines, washery refuse containing less than 50 per cent combustible can be used profitably, especially if the furnaces are designed for burning such fuel.

Some time ago the Bureau of Mines made a boiler test with washery refuse containing 41.8 per cent of ash, 10.8 per cent of moisture, 47.4 per cent of combustible. The test was made under a 200-hp. Heine boiler set up with ordinary hand-fired furnace with plain grate. About 75 per cent of the rated capacity of the boiler was developed with average over-all efficiency of 47.5 per cent. Of the 47.4 per cent of combustible in the fuel, 8.6 went with the ashes into the ashpit, an equivalent of 22.5 was absorbed by the boiler, an equivalent of 10.4 went up the stack with the gases, and the equivalent of 5.9 was lost by radiation, incomplete combustion, and moisture in fuel. The largest loss was up the stack due to large excess of air. The draft was 0.92 in. at the base of the stack, 0.06 in. in furnace, and 0.75 in. pressure in ashpit. The average thickness of fuel bed was 16 in. The fire was cleaned every hour. On account of the necessity of this frequent cleaning the average capacity fell below the rating of the boiler, although between the cleanings of fire the capacity developed was above the rating. It was also due to this frequent cleaning that the stack losses were high.

The essential requirement for the economical burning of high ash fuels is a continuous and automatic removal of ash from the furnace, so that the operation of the boiler need not be interfered with by frequent cleaning of fires.

A few weeks ago the Bureau of Mines received a letter from the president of a mining company, who was planning a furnace for burning washery refuse running about 40 per cent of combustible. This is a step in the right direction; the only place where it may be profitable to burn washery refuse or any other low-grade fuel is right at the source of such fuel so that the freight on the high ash is eliminated from the cost of the fuel. It would be wrong under the present railroad-car shortage to ship high-ash coal from the mines. At present the production of the coal mines is about 30 per cent below normal, and most of the deficiency (about 26 per cent) is caused by shortage of railroad cars. Therefore, the available railroad cars should be used only for hauling clean coal.

B. S. Murphy.[1] The following notes are based on data from the Hudson & Manhattan R. R. Co., and especially from its Jersey City power station, which is an anthracite-burning steam-electric plant for an electric railway

The boiler equipment consists of nine 900-hp. Babcock & Wilcox boilers, eight hand-fired and one equipped with a Coxe mechanical stoker.

The fuel is anthracite of the small sizes. Our practice is to use Nos. 3 and 4 buckwheat mixed with bituminous and some No. 1 buckwheat, this latter with no soft coal added. All fuel, 115,000 tons of anthracite in 1917, came from the same contractor, and approximately all of it originated from the same collieries, so that the combustible portion of the coal should be relatively the same. On the graph, Fig. 3, I have plotted the calorific value of the fuel by months in 1916 and 1917 with the first three months of 1918. In Table 1 are given the yearly averages and the maximum and minimum months during the year.

TABLE 1 CALORIFIC VALUE OF COAL AS FIRED, B.T.U.

Year	Minimum	Average	Maximum
1911	11,230	11,523	11,750
1912	11,050	11,428	11,650
1913	11,450	11,741	12,000
1914	11,550	11,912	12,050
1915	11,550	11,712	11,900
1916	11,150	11,563	11,850
1917	10,850	11,170	11,350
1918 (4 mos.)	10,750	10,900	11.150

An ash analysis gives relative values for the ash content of coal, but the true test is the proportionate amount of furnace refuse as compared with coal fired. Such a figure, taking into account the unconsumed carbon as well as the ash and other incombustibles for the amount and kind of ash, has a great

[1] Chief Engineer, Commonwealth Edison Co., Chicago. Mem. Am.Soc. M.E.

[2] Engineer, United States Bureau of Mines, Pittsburgh, Pa. Mem. Am.Soc.M.E.

[1] Superintendent of Power, Hudson & Manhattan Railroad Company, Jersey City, N. J. Mem. Am.Soc.M.E.

bearing on the fuel in the ash, especially for hand firing. The average values of this for 1917 and 1918 are shown in Fig. 4.

From the foregoing it is evident that there has been a marked deterioration in our coal. The resultant economic effect I have shown in Fig. 4, which gives the average relation between the calorific value of the fuel as fired and the relative overall plant economy. This has been plotted by the relative percentages, that is, assuming that the best coal we could

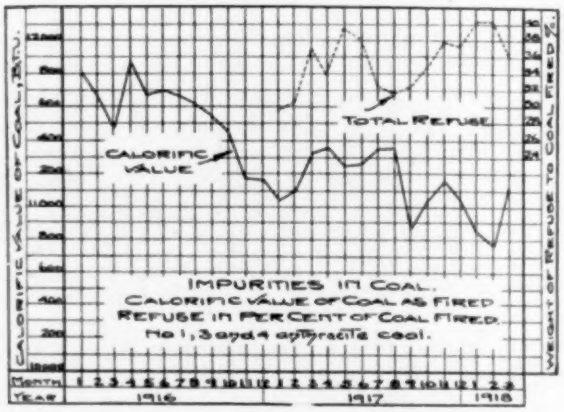

Fig. 3 Showing Fluctuation in Heating Value and Refuse Content

expect would give a plant economy of 100 per cent, then a coal of 10,500 B.t.u. will give but 53 per cent of this value, and extending the curve it becomes zero at about 9,000 B.t.u., or the effective range is from 9,000 to 12,000 B.t.u. In figuring the effect of a decrease in calorific value of the coal under consideration, this range should be used and not the whole range down to zero B.t.u.

Effect of High Ash

Some of the poorer coals have ash by analysis as high as 24.45 per cent, with 10,294 B.t.u. calorific value of wet coal, while the better ones have only 9 per cent with 12,000 B.t.u., or a 15 per cent difference. On the calorific-value graph this is plotted, and though the curve is not extremely accurate, it would indicate that the limit for our coal was reached with about 30 per cent ash, this having a greater effect on the mechanical manipulation of the fires than on the lack of heat value.

The above is based on hand-fired operation where the impurities content and kind of ash has a much greater influence than with stokers. The railroad load having marked morning and evening peaks is subjected to this much more than a plant with an average all-day load. The presence of impurities builds up the fires so rapidly that at times it is difficult to get through the service period without cleaning and necessitates the carrying of high ashpit pressures, at times 7 in. water gage, to burn the fires. Another noticeable feature that we have found with the No. 1 buckwheat is the formation of a light, puffy ash that builds up the fires so rapidly that they last only about three-quarters of an hour between cleanings, while an analysis of this same fuel shows but 16 to 17 per cent (gravimetrically) of ash, or a normal ash content, again showing that too much dependence cannot be placed on laboratory analysis for the effect on the fuel of the ash. As a rule, with anthracite the ash does not fuse into large, hard clinkers found with many kinds of bituminous coals; but even this has been noticed during the past winter, some of the clinkers being so large and so hard as to necessitate their removal through the fire doors instead of through the ash hopper.

Unconsumed Carbon in Refuse. In our station it is necessary to force the boilers during the service hours to 140 to 150 per cent rating. To do this with good firemen and good coal is not difficult, but when the impurities increase and the quality of men falls off it is extremely hard, one affecting the other. It is necessary with the good grades of No. 3 buckwheat to level fires about every eight minutes, and with the high impurities and uneven spreading it should be done every three or four minutes. This is heavy, hot work; it is much easier to "bail" in coal, and the result is that the fire continues to build up because the ash and coked coal are covered with green coal until the fire becomes so heavy that it is impossible to get air through it. Cleaning then wastes a large amount of unconsumed carbon to the ashpit. The magnitude of this loss is shown in Table 2. With good fuel and well-trained, willing firemen this has been brought down to less than 20 per cent.

TABLE 2 LOSS OF COMBUSTIBLE TO THE ASHPIT

Month—1918	Unburned Carbon in the Refuse, Per Cent
January	44.10
February	39.24
March	40.39

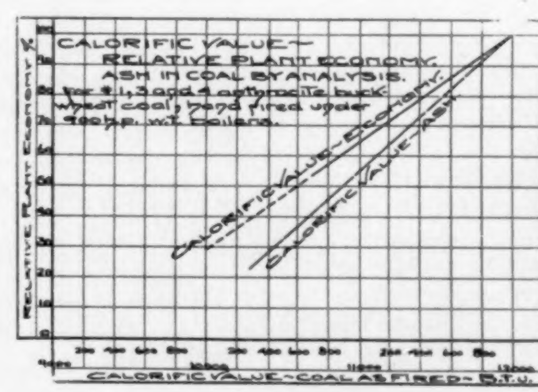

Fig. 4 Influence of Ash Content and Heating Value of Coal on Plant Economy

Summary. Summing up for the conditions as outlined for hand-fired boilers with the present grade of firemen available using Nos. 3 and 4 buckwheat coal with a relatively small percentage of bituminous, we find the following:

Calorific value, low limit, 10,200 B.t.u.; ash, high limit, 30 per cent, depending upon the behavior of the impurities.

Effect on Plant Economy: An increase in consumption per kw-hr. of 53 per cent from 12,000 B.t.u. to 10,500 B.t.u. coal. More coal is consumed, more coal is handled to the bunkers and to the fires and more refuse removed, increasing the unit cost of power.

Effect on Personnel: Much hard work for firemen with the result that the better men leave for easier work, poorer men hired who use proportionately more coal and consequently make more work for themselves.

Capacity: The capacity of a plant is limited by the small evaporation per pound of coal and the much shorter periods between cleanings.

Remedy: If the amount of impurities and the correspondingly low calorific value cannot be remedied at the mines, where some of this should be eliminated, then the remedy at the fire room is the increasing of the bituminous-coal content in the mixture, the introduction of mechanical stokers and the training of firemen, if the men can be induced to stay long enough to be trained.

R. H. Kuss.[1] Close observation supports the following views:

It is feasible to arrive at accurate conclusions on the subject of comparative performances in well-conducted plants only, since ash-variation effect is obscured when accompanied by operation slovenliness.

The well-conducted plant employs its available draft intensity to advantage, meaning by this that the unit rate of capacity tends to be such as to demand strict attention to tightness of settings, baffle repairs, cleanliness, etc., resulting in a comparatively high rate of combustion where slovenly methods are not permissible.

A marked increase of ash content in the coal compels a reduction in the usual unit capacity rate due to greater grate-refuse resistance.

A corollary effect is to carry thinner active fuel beds, attended with unevenness of air distribution through like grate zones in order partially to overcome the disadvantages of lower capacity rates.

With a surplus of draft the ill effects of ash increases can readily be overcome, though plant practice as to firing methods must be modified to suit.

Where extra draft intensity is employed to overcome increased fuel-bed resistance due to extra ash, the necessity for setting tightness is increased.

The usual condition is that available draft intensity is deficient, and there is no choice but to operate at lower capacities, thereby causing plant standby fuel losses due to radiation, banking, blow-downs, soot blowing, combustible in the refuse, etc., to increase.

The writer customarily attributes one-half of one per cent as a justifiable decrease in efficiency for every one per cent increase in ash content, but believes this to be a fair figure only when the increase does not exceed ten per cent of the total in ash content as revealed by a chemical analysis of the coal as fired.

A. S. Vincent.[2] The building of which I have charge is the largest apartment house in the world, occupies a whole block, has 175 families and is thoroughly equipped with a high-class isolated plant. Our horsepower-hour outputs for 1916 and 1917 were almost identical, and yet for 1917 consumed nearly 1000 tons more than we did in 1916, due only to the inferior grade of coal. In other words, the coal consumption in 1916 was about 7000 tons and in 1917 it was 8000 tons. This plant is equipped with everything an engineer could desire to enable him to keep plant records.

Our cost per boiler horsepower-hour in 1916, including all overhead charges, was \$0.0114 and for 1917 was \$0.017, due almost entirely to the excess coal used and at a cost of more than double the 1916 cost.

Albert A. Cary.[3] In an investigation made in a number of the largest power houses in the East during the latter part of 1917 in the interest of fuel conservation and its bearing upon the transportation problem, I found that over 30 per cent of all transportation facilities carrying bituminous coal were burdened with unnecessary impurities. By unnecessary impurities I mean those above the normal ash which had been carried in the coal when the power houses were obtaining their coal under specifications defining the minimum B.t.u. per pound of coal and maximum ash content acceptable.

[1] Consulting Engineer, Chicago, Ill. Mem. Am.Soc.M.E.

[2] Superintendent and Mechanical Engineer, The Belnord Apartments, New York City. Assoc. Am.Soc.M.E.

[3] Consulting Engineer, New York. Mem.Am.Soc.M.E.

A. J. German[1] (Oral). Our experience with the impurities in coal has been interesting. We at first had trouble unloading the coal in that the foreign matter in the coal broke the crusher gears. More trouble is given when the coal comes into the automatic stokers. Then there is the further damage done to the furnace side walls and to the bridge walls. When about to unload coal we try to pick out the slate and rock on top of the car. We picked up pieces last winter as large as 4 ft. in length, 2 ft. in width and 5 in. in thickness. We picked out 9000 lb. of such material from three forty-five-ton carloads.

We use coal crushers with one set of rolls with bearings having spiral springs so that the rollers may give way and pass a too solid piece of material, such as rock and slate. Nevertheless, we had considerable trouble with the breaking of the crusher. To avoid this we put in relays with an automatic overload release. This stopped the trouble, which may be considered to have been rather severe inasmuch as we broke six gears, three shafts and a number of bearings last winter. We use a chain-grate stoker, and we have found that the great increase in the amount of dust in the coal allows a considerable quantity of the screenings to fall through the grate. We catch these in a hopper placed under the front of the stoker.

R. J. S. Pigott[2] (Oral). In connection with the points brought up with regard to the effect of the increase of non-combustible material in coal, it is quite true that both the efficiency and capacity are seriously affected in hand-fired plants. It is found, too, that with the proper operation only capacity is seriously affected. In two well-operated plants, the efficiency of the boiler room has not been seriously affected by bad coal; but the capacity and maintenance of the equipment are affected. The increase in ash cuts down the heat value, or B.t.u., that can be developed per sq. ft. of grate per hour. Of course, the increase of ash simply cuts down the B.t.u. that one can get into the furnace per sq. ft. of grate. The trouble is that many plants, due to the large increase in ash, have to run close to their safe margin of capacity, and, as it is difficult, at this time, to get additional apparatus, the trouble is a serious one. Therefore it is the hand-fired plant that suffers most seriously from this condition, and it is that plant to which the Fuel Administration will have to give the greatest amount of help.

P. W. Thomas.[3] The incombustible portion of the coal limits the actual amount of heat contained in one pound of coal; its nature determines the percentage of contained heat which will be available for initial furnace temperature, and the components of ash have more bearing upon stoker design and furnace design than those of the combustible portion of the coal.

[1] Waterbury, Conn.

[2] Consulting Engineer, Bridgeport Brass Works, Bridgeport, Conn. Assoc-Mem.Am.Soc.M.E.

[3] Fuel Engineer, Central Coal & Coke Co., Kansas City, Mo.

The following functions of the stoker are affected by the quantity and nature of the ash:

a Weight of coal fed per unit of heating service per hour
b The character of the fuel bed
c The coking time of the combustible coal
d The nature of the coke residue
e The proper diffusion of air admitted
f The actual mechanical performance of both moving- and stationary-stoker metal.

The design of the furnace is greatly affected by the nature of the ash and should be such as to avoid the following defects:

1 Impregnation of firebrick with slag formation
2 The building up of the smaller particles of fusible ash in the furnace, by which the throat is restricted.

Another item of consideration with respect to the ash, especially in horizontally baffled boilers, is that the velocity of the gases through the first pass must either be slow enough to deposit the ash particles in the combustion chamber or sufficiently strong to carry them toward the last pass to a lower temperature. If deposited in the first pass in a high temperature, they will build on the tubes and bottle the furnace.

To our minds, then, the stoker should be selected after an investigation of the ash in the coal to be used. A typical analysis of fluxing ash is given below:

Silica as oxide	43.50
Alumina	17.10
Ferric oxide	28.10
Calcium oxide	5.30
MgO	0.75
Sulphur (sulphide occluded in CaO)	2.75
Carbon dioxide	trace
Carbon unburned	1.90
Alkali	trace
Moisture	trace
	99.40

Probable fluxing temperature, 2138 deg. fahr.

(Cosgrove states that silica melts at 3227 deg. fahr. A silicate formed by the combination of FeO and SiO fuses at 2318 deg. fahr., and if part of this silica is replaced by 16 per cent CaO, the resulting iron-lime silicate will fuse at 2138 deg. fahr. The above ash, if considered from the standpoint of these three metals, contains 57 per cent silica, 37 per cent iron, 16 per cent calcium.)

If the slag is allowed to accumulate in any receptacle such as a dump grate or ash pocket, its peculiar viscous nature will invariably cause trouble. Sooner or later the mechanism of the ash dump will clog, with a resultant shutdown for repairs to both ash pocket and grate.

If any of these coals is carried on a thick fire, an inversion or disturbance of the fuel bed will precipitate an ash run in the fuel bed proper. The slag is so heavy that I have known it to settle down into the tuyere boxes against a pressure of 5 in. of water, and within two hours close the entire air supply of the furnace.

Once the air is shut off, the condition becomes aggravated in the following manner: The pyrite FeS_2, instead of oxidizing to the relatively harmless ferrous oxide, reduces to ferrous sulphide, FeS, which has the same fluxing temperature as the ferrous lime silicate, 2138 deg. fahr., but when the FeS melts, it runs over the metal of the furnace and destroys it. Troughs and dead plates are warped and wasted. A run of molten iron sulphide through a grate of any type will in a few hours carry enough metal from the stoker to the ashpit to shut the boiler down.

2 To What Extent Is Fuel Oil Likely to be Used as a Substitute for Coal?

Information is desired as to present use, advantage found, probable available supply, etc.

ERNEST H. PEABODY.[1] At the end of 1914, the total aggregate world output of oil since 1857 had reached the enormous total of about 5,500,000,000 bbl. (of 42 U. S. gal. each), of which the United States had produced about 60 per cent. By the end of 1916 this had risen to 6,478,944,229 bbl. In 1916, it is estimated, there were produced 460,639,407 bbl., of which the United States produced 300,767,158 bbl., or 65 per cent.

The data in Table 3 are from the preliminary report of the U. S. Geological Survey, and show that in the year 1917 the production in the United States had increased some 14 per cent over 1916, reaching the record-breaking total of nearly 342 million barrels.

FORTY PER CENT OF OIL AVAILABLE FOR FUEL PURPOSES

At least 40 per cent of all the crude oil produced will be available for fuel purposes. Notwithstanding the great amount required for war purposes, particularly in the Navy and the rapidly increasing merchant marine, it is well worth asking whether or not oil fuel can be obtained for steam production on shore.

No definite statement can be made as to the availability of oil in any particular locality, especially under the existing conditions. At all times, in fact, this is purely a local question. In California, until recently our largest oil-producing state, and where no coal of importance is mined, oil will doubtless continue to displace coal. In Pennsylvania, on the other hand, there are great coal deposits, while the oil produced is of a variety exceedingly valuable for refining purposes, so that coal as fuel holds decided superiority over oil except for special uses. In other portions of the country the balance may fall either way—as the production and the demand vary and as the transportation problem may determine. It would

TABLE 3 FUEL-OIL PRODUCTION BY DISTRICTS IN 1916 AND 1917

Field	1916	1917
	Barrels	Barrels
Appalachian	23,009,455	24,600,000
Lima—Indiana	3,905,003	3,500,000
Illinois	17,714,235	15,900,000
Oklahoma—Kansas	115,809,792	147,000,000
Central and Northern Texas	9,303,005	11,000,000
North Louisiana	11,821,642	8,700,000
Gulf Coast	21,768,096	24,900,000
Rocky Mountain	6,476,289	9,200,000
California	90,951,936	97,000,000
Other Fields	7,705	....
	300,767,158	341,800,000

[1] Consulting Engineer, Babcock & Wilcox Co., New York City.

seem as if the Middle West should be well supplied with oil, as Oklahoma now produces more than one-fifth of all the oil in the world. Oklahoma wrested the production laurels from California in 1915.

The Mexican production, while already very large (nearly forty million barrels in 1916), has been restricted on account of a deficient amount of tonnage to take the oil away. With adequate shipping facilities it is probable that the Mexican fields will constitute the natural source of oil-fuel supply for New England and the Atlantic states. There is one well alone in Mexico, the Cerro Azul, estimated to have flowed 263,000 bbl. a day, and it is interesting to speculate on what these fields may finally produce.

All indications point to the probability that there are enormous quantities of oil yet hidden in the earth's crust to be one day brought forth by the prospector.

Care Required to Prevent Waste of Oil

A coal fire in the hands of a lazy or incompetent fireman may indeed fall far below the desired standards of excellence; but it can only reach a certain minimum level of efficiency, and then it will go out. Coal is, in fact, of such a nature that it will quietly stand a certain definite loss in economic results, and then it will quit.

With oil there is no limit to the possible wastefulness that may exist. Give it poor burners, improper furnace conditions or not enough draft, and it will smoke and sputter and drip oil and waste itself away, but never give up. Give it too much air, a hundred times too much, and the fire will burn, the oil will disappear, the flame will be bright, there will be no smoke; but the waste may be so great that the boiler will not make enough steam to run the feed pump, even with the best furnace and burner arrangement.

It is approximately true that 1 lb. of oil equals $1\frac{1}{2}$ lb. of coal in actual steam-making results. Roughly, this is equivalent to saying that 200 U. S. gal. of oil equals one ton (2240 lb.) of coal, or one ton of coal equals about $4\frac{1}{2}$ bbl. of oil.

A very handy rule, but like the rest only approximately correct, is this:

> When the price of coal in dollars per ton (2240 lb.) is double the price of oil in cents per U. S. gallon, the cost of fuel for producing a certain boiler capacity will be the same for both fuels. Thus two-cent oil equals $4 coal, or four-cent oil equals $8 coal.

This rule takes into consideration the probable increased boiler efficiency obtainable with oil, but makes certain assumptions concerning the heat values of the two fuels and the weight of the oil per gallon which, while generally representative, may or may not be correct in any specific instance.

Generally speaking, one oil burner will be required for, say, 350 to 400 boiler hp., and one oil fireman can attend to about ten burners.

Reliable tests with oil fuel have shown that the boiler efficiency (i.e., the percentage of heat units in the oil which is actually absorbed by the steam leaving the boiler) may be as high as 83 to 84 per cent, although 78 to 80 per cent may be considered as good work, or even 75 per cent, in regular operating conditions. With coal fuel, while reports have been published by some pseudo authorities showing over 80 per cent, the writer believes that such high results with coal can only be obtained with very large boiler units and the most efficient mechanical stokers. Certain it is that in hand-fired plants, 75 per cent is about the maximum, while 65 per cent may be considered very good average work.

The advantage possessed by oil in respect to increased efficiency is due primarily to the small amount of air required for complete combustion in excess of the theoretical amount. This may be reduced to 10 per cent with oil, while the best tests with coal, hand-fired, show about 50 per cent, and good every-day working conditions run as high as 80 or 100 per cent.

Maintenance Less with Oil than with Coal

Maintenance charges are decidedly less than with coal. It is true that higher furnace temperatures with oil as a rule require a better quality of firebrick, and danger may result to boiler heating surface with improper furnace arrangements and burners. These points are easily cared for.

The theory of burning oil is different and radically distinct from that controlling the burning of solid fuel. Pulverized coal of course in some respects closely approaches the character of burning oil, but coal fired by hand or by stokers remains substantially at rest during combustion, and the air is brought to it. In the case of oil, the fuel is moving and the air moves with it.

In varying the rate of combustion of coal, the amount and velocity of the air through the fuel bed is altered—the intensity of the draft is increased or decreased. In the case of oil, the amount of fuel itself and the rate at which it enters the furnace must be varied, and the amount of air entering with it must be increased or decreased to preserve the proper ratio.

The lighting of an oil fire is a simple process. The oil pump is started to give the necessary oil pressure at the burners. The draft is opened to provide sufficient air for combustion. A lighted torch is then placed directly under the burner tip, and the oil is then turned on. If the oil is at the proper temperature and the atomizer is working properly, the spray at once bursts into flame. The spray must never be started without first lighting the torch; i.e., no oil must be injected into a "dark furnace," for if it is, an explosive mixture may be formed in the furnace which will cause damage if ignited.

There is little or no difference in the action of compressed air and steam in atomizing oil as far as boiler work is concerned, and if the air is compressed to over 30 lb. per sq. in. there is no special difference in the design of the burner itself.

So far as the steam-boiler furnace is concerned, however, the prospective user of oil may forget the air atomizer, the one instance in which its use might be considered being that in which the saving of fresh water (consumed by the steam atomizer) is a matter of importance. And in this case a mechanical atomizer will probably do the work effectively, and will be preferred.

Selection of Type of Burner

As between the claims of the steam atomizer vs. the mechanical atomizer, the issue is not as clear cut. On board ship, except in the case of harbor vessels or those making port every day, the steam atomizer has given way to the mechanical atomizer, where the saving in fresh water for the boiler makes the use of the latter type practically imperative.

There is practically nothing to choose between the two types in operating results under equivalent conditions. The steam atomizer is, however, more flexible, i.e., the individual burner has a greater range in capacity; it costs less to install, notwithstanding that it requires two lines of pipe (oil and steam), whereas the mechanical uses only one, and that for the

oil. It is more readily applied to a coal-burning furnace, and conversely the furnace is more quickly converted back again to coal. It requires a lower oil pressure and not so high a temperature for viscous oils. It will also, in general, require less draft to operate. Furthermore, where special arrangements of burners are required, as in the case of the so-called "back-shot" burner (placed at the rear of the furnace), the steam atomizer is susceptible of a wide range in design which has been found useful.

Oil Pressure and Temperature

For steam (or air) atomizing burners, oil pressures of 25 to 50 lb. at the pumps are adequate, and under certain conditions even less pressures. Overhead tanks a few feet above the burners, feeding the oil by gravity, have been employed, but this is inadvisable on account of danger of fire, and pumps are usually employed. Mechanical burners require pressures of 50 to 250 lb. at the burner tip, 200 lb. being a favorite pressure for the designer. The wide range of pressure is useful in adjusting the burner capacity. A steady oil pressure is a necessity for oil burners, a vital necessity for mechanical burners. Therefore large air chambers on the oil line are needed if the usual duplex reciprocating pump is used. Rotary pumps are being introduced in the Navy, and recently the screw pump has come into vogue. These pumps give a steady pressure of oil with little or no air cushioning, and the screw pump, particularly, seems to possess great possibilities for this work.

The matter of heating the oil is rather of a mechanical nature as its importance bears on the viscosity of the oil rather than on any thermal advantage. Steam atomizers will handle more viscous oil than the mechanical type, therefore steam heaters using exhaust steam from the pumps and capable of heating the oil to 100 deg. to 125 deg. fahr. are usually satisfactory. The mechanical burner requires that the viscosity of the oil be reduced to 8 to 10 deg. Engler to spray properly, and this means that the oil (according to its viscosity) must be heated to 120 deg. to 280 deg. fahr. The latter temperature is required for heavy viscous oils that are appearing on the market to a greater and greater extent. In a mechanical-burner installation it is evident that the oil heater is a most essential part of the equipment.

Importance of Air Regulation

To a certain extent the amount of air being delivered to an oil fire is indicated by the color of the flame, a very bright, intense white (so desirable with coal) usually indicating that too much air is being used, with a resulting loss in efficiency. Judging the fire by the flame, however, is only approximate; and it is better to resort to the simple device of diminishing the air supply until a light brown haze appears at the top of the chimney. This is preferable to a clear stack, as the latter gives no indication of excess air. The light haze is not at all objectionable but represents good conditions, provided—and this is a most important point—the smoke which produces the haze does not come from one or two burners only, while all the rest are working with oil. Complete combustion in the furnace (that is, combustion in which all the carbon is burned to CO_2 and no CO is present) will give an analysis with coal in which the CO_2 content, plus the free-oxygen content, will add up considerably higher in amount than an analysis of the products of similarly complete combustion of oil. The same percentage of CO_2 in the gas sample from coal indicates a much greater excess of air over that theoretically required than when oil is being burned. However, complete combustion of oil can be secured with a much lower amount of excess air than coal fuel; and it happens, therefore, that 14 per cent CO_2 in both cases represents the same satisfactory conditions in the furnace with both fuels.

The amount of air theoretically required for the complete combustion of fuel oil of course varies with the composition of the oil, but it may be considered that about 14 lb. or 183 cu. ft. at 60 deg. fahr. represents the average.

Boiler Furnace for Oil Fuel

In oil burning, "furnace volume" possesses a function similar to that of "grate area" in burning coal fuel. The rate of combustion of oil per cubic foot of furnace volume may be increased or decreased according to the intensity of the draft. A large furnace is necessary, therefore, if the draft is low, and the furnace can be made smaller if the draft is increased. This effect of furnace volume on the rate of oil combustion is often ignored or misunderstood; but it is of prime importance.

A high furnace temperature promotes the combustion of oil. Owing to the less quantity of excess air, oil furnaces are usually higher in temperature than those burning coal, so that good-quality firebrick with a fusing point at least 3000 deg. fahr. should be used. Notwithstanding the higher temperature, if the burners are set and operate properly so that no flame impinges on the wall and no hard carbon is deposited, the wear and tear should not be great.

W. N. Best.[1] The direct answer to this inquiry is: First, in whatever equipment oil as a fuel is found to be cheaper than coal; second, whenever by its use an increased output is secured; third, wherever a superior quality of metal is produced; fourth, to safeguard against shutdowns in power plants through shortage of other fuels; and fifth, to carry peak loads in power plants.

We will first consider oil in power plants. If the coal used has a calorific value of 14,000 B.t.u. per lb. (good bituminous coal) it requires 147 gal. of oil to represent a long ton of coal (2240 lb.), the oil having a calorific value of 19,000 B.t.u. and weighing 7.5 lb. per gal. With oil at 5 cents per gal., this would be equivalent to coal at $7.35 per ton delivered in the coal bin. The larger the power plant, the more attractive is oil fuel, owing to the fact that one man can fire and water-tend twelve 300-hp. boilers. There are no ashes to handle and cart away. Of course the saving on all labor such as extra firemen and ash handling will vary in accordance with the number and size of boilers in the plant. I only mention this as a concrete illustration as to how an engineer can calculate the cost of the two fuels, so that anyone can definitely determine if oil is attractive or not. The data used has been compiled from hundreds of tests.

In the eastern part of the United States oil as a fuel is rarely found to be as cheap as coal when used exclusively as a fuel in boilers; but last winter's experiences fully demonstrate the necessity of having coal-fired power plants equipped with oil as an emergency fuel owing to the uncertainty of the coal supply, and also the delay in delivery occasioned by the shortage of coal cars. It is the writer's opinion that no power plant today is safe without apparatus for the use of oil as an emergency fuel. Also, oil may be used as an emergency fuel to carry peak loads on either hand-fired or stoker-fired boilers. The liquid-fuel-injecting apparatus may be placed in the side wall of the boiler, midway between the bridge wall and

[1] President, W. N. Best, Inc., New York, N. Y.

front-end setting or may be placed in the front-end setting and will not interfere with the fireman or stoker. A lever is used to operate the slide gate which admits the air to support combustion, independent of the air admitted through grates or stokers; thus, if it is desired to operate the oil burner at 15 per cent of its capacity, the gate is only opened sufficiently to admit just enough air for the perfect combustion of that amount of fuel in combination with the coal. It can be so operated that no superfluous air is admitted into the firebox by simply moving the lever to any position required. As soon as the supply of coal is entirely exhausted, the grates or stokers can be covered with cinders and oil burned exclusively. When a supply of coal is again secured, the cinders or ashes can be removed, the burner shut off and the air gate closed while only coal is again burned.

There are thousands of boilers in power plants and in gas works where to carry peak loads oil or tar is burned in combination with coal, breeze, etc. Also in power plants where bagasse is used as a fuel often oil is necessary to aid that fuel in obtaining the full rating of the boiler. Oil is an ideal fuel for this purpose, for by its use one can control and maintain the steam pressure as desired. It ordinarily requires three gallons of oil to each ton of bagasse burned.

I believe all marine boilers now burning coal should be equipped with oil as an emergency fuel, especially should this fuel be used in the time of war, for by its use in combination with coal the boilers can be operated at 200 per cent overload in a few minutes, thereby increasing the speed of the vessel to its maximum.

In forging plants oil should be used as fuel, for thereby the manufacturer secures the maximum output and a better quality of metal. In this practice 80 gal. of oil are equivalent to a ton of good coal.

In heat-treating furnaces (low temperatures) 72 gal. of oil are required to represent a ton of coal of the calorific value referred to. Since it is true that steel is only as valuable as it is heat-treated, oil is superior to coal, for by its use in modern furnaces any temperature required can be attained and maintained at the will of the operator, and an even distribution of heat obtained over the entire charging space of furnace.

In foundry practice oil is an incomparable fuel for core ovens, and in steel foundries for mold-drying ovens, etc.

In chemical plants where accuracy of temperatures is very important, especially in the manufacture of dyes, oil fuel is a necessity.

In welding flues 58 gal. of oil represent a ton of coal (all coal and oil referred to here have the same calorific value). This is due to the fact that it is necessary to coke a coal fire before welding two pieces of metal together, and in this process of coking the coal all the volatile gases are wasted.

In conclusion, I would say that owing to the superior qualities of oil, it belongs to that portion of the manufacturing world having forging and heat-treating shops, foundries melting various kinds of metals, and power plants for which an emergency fuel must be provided. I am confident that when the war is over the nation having control of the most oil wells will be the largest manufacturer in the world; and if Germany controls the oil fields of Roumania, and the Baku fields of Russia, our country's greatest competitor in the manufacturing world will be Germany, although we (the United States) now contribute 62 per cent of the world's production of crude oil. We must conserve this fuel and only use it where it can best serve the nation.

R. J. S. Pigott. One very important point militating against the substitution of fuel oil for coal, (even if a supply were obtainable, which it is not), is the relative price of fuel oil and coal per million B.t.u. In all but the most favored localities, coal is about one-half, or less, the cost of fuel oil per million B.t.u. For instance, at Bridgeport in 1915, coal was $4 a ton (14,250 B.t.u.) and oil 4 cents per gal. (19,000 B.t.u.); the relative cost was 12.65 cents per million B.t.u. for coal and 29 cents per million B.t.u. for oil. Any one contemplating the substitution of oil for coal would be faced with a doubled cost of steam production. The saving in labor due to elimination of coal- and ash-handling is insignificant. The difference in efficiency is now next to nothing, since the development of the underfeed stoker has put the coal-fired boiler practically on a par at all points with oil.

One very large source of waste, and an immense opportunity for saving, lies in our industrial heating processes. We have vast amounts of coal, oil and gas used in factory processes for heat-treating, annealing, pit fires, forge furnaces, etc., in nearly all of which cold work is introduced directly into an intensely hot chamber under direct flame, and no attempt whatsoever made to use the heat in the flue gases.

In connection with the writer's work at the Remington Company, we tested several types of oil-fired forge furnaces, as well as gas-fired brazing and other small-operation furnaces, finding the efficiency between 10 per cent and 15 per cent. In some cases, surface-combustion or semi-surface-combustion furnaces of our own design were substituted for Bunsen-flame types, cutting down gas to one-third, and in two cases, to one-fifth the former amounts. We should by all means employ preheating methods in our shop operations, making use of the familiar countercurrent principle so universally adopted in such heat-transfer apparatus as condensers, feed heaters and boilers. There is no question but that we could at least double the present poor efficiency of our usual primitive shop furnace.

Referring to the coal situation, the admirable work of Mr. Potter and Mr. Cole in Pennsylvania should have the hearty support of this Society, since it is a method of curing the cause, not the effect,—which eases the situation both from the coal burner's point of view and that of the transportation company. I therefore respectfully submit the following resolution:

Whereas, A large proportion of the shortage of fuel is due to the reduction of capacity and efficiency occasioned by the increase in non-combustible impurities in the coal as furnished from the mines, due chiefly to negligence on the part of the operators; and to the consequent increase in tonnage hauled for a given total heating-value.

Whereas, Mr. William Potter, Fuel Administrator of Pennsylvania, has taken effective steps to force the proper cleaning of coal by establishing inspection at the mines, standards of quality and punishment for infraction; be it

Resolved, That the members in attendance at the Spring Meeting of The American Society of Mechanical Engineers indorse and support the action of the above-mentioned Fuel Administrator of Pennsylvania.

C. H. Delany.[1] To engineers on the Pacific Coast where fuel oil has for many years been the only fuel available, the problem at present is, what fuel can be substituted for fuel oil, rather than to what extent can fuel oil be substituted for coal.

[1] Pacific Gas and Electric Co., San Francisco, Cal.

During the past two years the price of fuel oil on the Pacific Coast has almost trebled, and in the Northwest its use has practically ceased, other fuels being substituted for it.

In California, where there is practically no coal available, the use of fuel oil still continues, but as the consumption at present is considerably greater than the production, it is questionable how long its use can be continued without restrictions.

Oil-Fuel Shortage Will Grow More Acute

The situation will shortly grow worse on account of the immense quantities of fuel oil required for the Navy, especially for the large number of destroyers that are now being built. It seems, therefore, that unless there is a considerable increase in the production of fuel oil, it is useless to discuss the possibility of its being substituted for coal; however, there is always a possibility of new oil fields being opened up.

In Table 4 a comparison is given of fuel oil with coal of heating values varying from 10,000 to 15,000 B.t.u. per lb. The heating value of the oil is given as 18,500 B.t.u. per lb., which is a fair average value for California oil, the variations from this value being small. It is well known that with good grades of semi-bituminous coal better boiler efficiency can be obtained than with the low-grade western coals, and to make this comparison fairly correct for the different grades of coal, an efficiency of 60 per cent has been assumed for coal having 10,000 B.t.u. per lb., and 75 per cent for coal having 15,000 B.t.u. per lb., with intermediate values for the coals that lie between these extremes. As the heating value of coal is invariably given on the basis of dry coal, and as coal when purchased invariably contains a considerable proportion of moisture, it has been assumed that the coals considered in this comparison contain 6 per cent moisture. In the case of fuel oil the water content does not usually exceed 1 per cent and this value has, therefore, been used in the comparison.

TABLE 4 COMPARISON OF FUEL OIL WITH COAL OF VARIOUS HEATING VALUES

(Coal containing 6 per cent moisture)

	Coal						Oil
B.t.u. per lb. dry fuel	10,000	11,000	12,000	13,000	14,000	15,000	18,500
Boiler efficiency, per cent	60	63	66	69	72	75	78
Dry fuel per boiler hp., lb.	5.58	4.82	4.22	3.73	3.32	2.97	2.32
Fuel as fired per boiler hp., lb	5.94	5.13	4.49	3.97	3.53	3.16	2.34
Coal equivalent to 1 bbl. oil (42 gal.), lb.	851	737	645	570	506	454	....
Price of 1 ton (2000 lb.) of coal equivalent to oil at $2 per bbl., dollars	4.70	5.43	6.20	7.03	7.92	8.82	....
Price of 1 bbl. of oil equivalent to coal at $5 per ton, dollars	2.13	1.84	1.61	1.42	1.26	1.13	....

The comparison given here considers only the actual value of the fuel itself. An oil-fired plant is considerably cheaper to build than a coal-fired plant, due to the lack of coal-handling apparatus, mechanical stokers, etc.; furthermore, the labor in the oil-fired plant is much less than in a coal-fired plant, consequently the actual comparison for any particular plant will be somewhat more favorable to oil than is shown in Table 4.

Fig. 5, which extends the information contained in the table to other prices of coal and oil, will serve as a rough guide for those who contemplate changing from one fuel to the other. The efficiency of 78 per cent for oil firing assumed in these calculations can be readily maintained in normal service provided proper attention is paid to the furnace design and the regulation of the fires.

Automatic Regulation of Fire

One of the greatest advantages of the use of oil as fuel is that it is possible to regulate the firing entirely automatically. It is well known that in the modern power plant the efficiency obtained depends very largely on the personal element in the fireroom. This personal element has been largely eliminated in the engine room by making automatic the regulation of modern prime movers. In the fireroom, however, it is customary to depend entirely on the judgment of the fireman to regulate the supply of air that will insure commercially perfect combustion and give the highest efficiency. By making this regulation automatic the method of operating the plant changes, for it is then only necessary to adjust the fires at the start, and if the automatic regulator is reliable, it will keep the fires in proper adjustment for all loads.

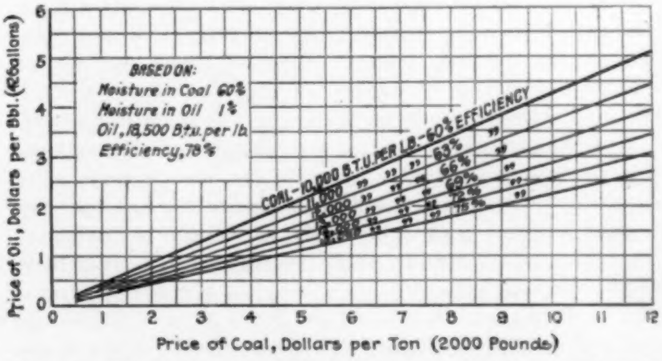

FIG. 5 COMPARISON OF FUEL OIL WITH COAL OF VARIOUS HEATING VALUES

Automatic regulators are now on the market for oil burning which regulate the quantity of oil, the quantity of atomizing steam and the quantity of air required for combustion. While the main advantage of the automatic device is that it insures the boiler operating at maximum efficiency at all times, it also has the advantage of causing considerable saving in labor.

This advantage will be especially true in the case of small isolated plants where the firing is of poor quality and where the cost of labor is large in proportion to the quantity of fuel burned, and it is in these small plants scattered throughout the country that the greatest benefit would be derived if it were possible to substitute fuel oil for coal.

W. G. WILLIAMS.[1] Prior to 1915 fuel oil offered coal keen competition in many parts of the country, but war conditions have placed a different aspect on the situation, and it is safe to say that the present conditions are far more likely to prevail after peace is declared than that pre-war conditions will obtain.

The requirements for petroleum products of the lower end points necessarily keep pace with the growth of the internal-combustion engine; that the production of crude petroleum has not kept pace is evidenced by the reduction of crude in storage. In 1916 there were 162,000,000 bbl. of crude in storage, and

[1] Efficiency Engineer, Empire Gas & Fuel Co., Bartlesville, Okla.

at the present rate of reduction this reserve will be exhausted in 1919.

According to available information, slightly over 300,000,000 bbl. of crude oil were run through American refineries in 1917, and from this 102,000,000 bbl. of gasoline and kerosene, and about 150,000,000 bbl. of gas oil and fuel oil, were produced. This fuel oil (considering gas oil as fuel) corresponds to a coal production of 37½ million tons, which is hardly to be considered in comparison with the actual and known potential production of coal.

Ships May Demand All Fuel Oil Produced

Certain localities and requirements make the use of other than liquid fuel practically out of the question. On the Pacific Coast oil will be used to the exclusion of coal until one of two things occurs—production of crude petroleum falls off, or a method is discovered of converting the output of crude into gasoline. In the marine industry oil is practically the ideal fuel, and with the enormous increase in shipbuilding in the United States it is not too conservative to say that our fuel-oil output is destined for almost exclusive use on shipboard.

It is true that the maximum output of the Mexican fields is still an unknown quantity, and that the known oil fields are only a small part of those yet to be discovered, but against this must be considered the proven life of the fields, and the efforts to convert crude petroleum into gasoline exclusively.

With the gigantic strides that are being made in the application of internal-combustion engines for motive power, the effort to produce a corresponding increase in the fuel for these engines is taking two forms, namely, an increase in production of crude, and of gasoline from the crude. How little these efforts are being rewarded is shown by the decrease in production in the Kansas, Oklahoma, and Texas fields of 82,000 bbl. per day since last October, and the practical failure of the "cracking" processes so far developed.

Any calculations based on the use of petroleum as fuel are, however, rendered valueless by the fact that any hour of any day may witness the development of a new oil field which will produce petroleum in such quantities that its use as fuel would largely supplant coal. The exhaustion of known fields is no bar to the discovery of new and larger producing areas, and I believe it is a wise engineer who keeps this possibility in mind, just as he would the ultimate development of a small steam plant into one of a size to eventually accommodate automatic coal-handling and firing equipment, and I believe this is particularly applicable to those of us doing business west of Pittsburgh.

C. W. Koiner.[1] No relief can be looked for in the East from the substitution of fuel oil for coal except for ocean-going vessels and, possibly, to a limited extent, for the reason that this oil would have to come from the southern and Mexican fields and the conditions in Mexico are so chaotic that the full supply of oil that these fields are capable of putting out cannot be depended upon.

Hydroelectric Plants Interconnected

Practically all hydroelectric plants in California have been linked together from the southern to the northern part, a distance of approximately 800 miles, with a view of eliminating oil-burning plants wherever possible. The oil reserve in California has, during the months of January, February and March, been drawn on to the extent of 1,655,000 bbl. The month of April, however, shows a little improvement. The production has been increased and the lack of shipping facilities for carrying the oil to its destination has prevented the reserve being depleted as much as during the past year.

[1] General Manager, Municipal Lighting Department, Pasadena, Cal.

Vast Deposits of Oil Shale

Guy Elliott Mitchell of the United States Geological Survey, in an article in the *National Geographic Magazine* for February, 1918, stated that the total production of petroleum in the United States up to 1918 was 4,255,000,000 bbl. In regard to future production, he estimates that the total amount in the ground, some of which lies very deep, is about 7,000,000,000 bbl. This is small compared with the quantity of oil that can be extracted from our oil-shale deposits. He tells us that American deposits of oil shale will supply enormous quantities of oil in the future. It is estimated that 20,000,000,000 bbl. can be obtained from the oil shale in Colorado alone; that certain ranges of mountains in which these deposits are located carry thick beds of rock that yield 30 to 100 gal. to the ton. The shale deposits of Indiana are estimated to carry 100,000,000,000 bbl. of oil. There are also deposits in Wyoming, Nevada, Illinois, Kentucky, Ohio, Pennsylvania, Tennessee and West Virginia; therefore our oil supply for the future is assured, even though we fail to develop additional oil territory other than the shale deposits.

Victor J. Azbe.[1] Fuel oil is the ideal fuel for boiler purposes. It gives high boiler efficiency, high boiler capacity, rapid regulation, low cost of handling, low cost of firing with hardly any disadvantages, but it should not be burned in localities with a coal mine only 30 miles off. In the southern states, especially Texas, plants are equipping to burn lignite in preference to the present expensive fuel oil, and those which are not should be made to do so.

Lignite is the best fuel to be burned in territory where available. Very good results can be obtained with it and 12 per cent CO_2 maintained without difficulty. With intelligent firemen in charge as high boiler efficiency will be obtained with lignite as with coal and it has not been unusual for the writer to obtain 65 per cent combined efficiency with ordinary return tubular hand-fired boilers; and with proper design boilers can be forced far beyond rating with lignite.

The value of wood as fuel also is not realized, and as an example I will mention a certain plant in Louisiana that burned oil for years at 80 cents per barrel. All at once the cost of oil increased to $1.40 and they began burning wood and during the next fiscal year the cost of fuel per unit of output was far less than with oil at 80 cents. To think of this and then of the enormous quantities of wood wasted throughout Mississippi and Louisiana and other states makes a man realize how unadaptable we are.

H. A. Barre.[2] Oil is practically the only fuel used for power purposes in California, except for a small amount of natural gas.

Originally it was burned as it came from the wells, but of recent years the crude oil is all topped for the lighter constituents, and the residual only, having a gravity of 14 deg. to 18 deg. B, used for boiler fuel. The unit of measurement is the barrel of 42 gal. weighing about 335 lb. and containing

[1] Junior Mem.Am.Soc.M.E.; Engineering Dept., Anheuser-Busch Brewing Asso., St. Louis, Mo.

[2] Southern California Edison Co., Los Angeles, Cal., Mem.Am.Soc.M.E.

from 6,000,000 to 6,200,000 B.t.u. Compared with 12,000-B.t.u. coal, one ton of 2000 lb. equals nearly four barrels of oil.

Before the war the price for favorable delivery points, such as tidewater and pipe-line terminals, was 60 to 70 cents, equal to $2.40 to $2.80 coal. At present the market is about $1.45 per barrel, equivalent to $5.80 coal per short ton.

These figures are not entirely just as a comparison, since the expense to store and fire oil is much less than for the corresponding thermal equivalent of coal. There are no ashes to dispose of, and ease of control in firing admits of higher operating plant efficiencies. The same amount of investment will therefore produce higher thermal efficiencies than with coal.

Two large and comparatively modern plants have been for some years under the writer's observation. One of these is of 40,000 kw. capacity, having three 5000-kw. engine-type units, installed in 1906, which are seldom used, and two 15,000-kva. turbines installed in 1910 and 1911. The other is of 47,000 kw. capacity, having one 12,000-kw., one 15,000-kw., and one 20,000-kw. turbine. This is much the better plant.

These two plants are a part of a large interconnected system having a total capacity of nearly 200,000 kw., and run in conjunction with a number of water-power plants.

They serve three functions—(1) As a steam reserve for breakdown of lines and other plants; (2) To supply kilowatt-hours during the season of low water; (3) To care for increases in load until these reach sufficient magnitude to justify bringing in additional water power.

The annual loads and load factors are, therefore, of an erratic nature.

The operating conditions for several years past are shown in Table 5.

TABLE 5 OPERATING CONDITIONS WITH FUEL OIL

	40,000 KW.			47,000 KW.		
Year.	Kilowatt-Hours Output.	Bbl. of Fuel Oil.	Kilowatt-Hours Per Bbl.	Kilowatt-Hours Output.	Bbl. of Fuel Oil.	Kilowatt-Hours Per Bbl.
1911....	126,377,000	574,178	220.03	....	......	....
1912....	150,801,000	732,444	206.00	50,300,000	240,537	209.0
1913....	163,015,000	756,652	215.44	94,046,000	439,454	214.0
1914....	18,588,000	161,190	115.30	74,812,000	347,008	215.7
1915....	5,274,000	88,576	59.50	77,556,000	328,749	236.0
1916....	3,785,000	81,783	46.30	45,360,000	218,235	207.5
1917....	4,930,000	83,692	58.80	133,528,000	562,177	238.0

It will be seen that the best annual operating results have been approximately as shown in Table 6.

In both these tables the results are net after accounting for station auxiliaries; that is, the measurements are oil delivered to the stations and kilowatt-hours output at the station feeders.

TABLE 6 BEST OPERATING RESULTS

Plant	Kilowatt-Hours per Bbl.	B.t.u. per Kilowatt Hour	Per Cent Efficiency
40,000 Kw..............	220	27,300	12.5
47,000 Kw..............	240	25,000	13.65

Some oil-burning plants having a high load factor have recently been put into operation in Arizona, operating at about 19,000 B.t.u. per kw-hr., or nearly 18 per cent efficiency.

In these two plants a 600-hp. B. & W. or Sterling boiler will carry with auxiliaries about 1000 to 1100 kw. of station output.

The arrangement of the furnace is more important than the type of burner used.

The oil is usually atomized by steam. The resultant spray is burned by mixing with the proper quantity of air and distributed evenly throughout the firebox without directly striking the surfaces of the tubes and furnace walls, but also without permitting the occurrence of blank spaces which might admit a surplus of air.

There are several types of burners, between which there is little to choose. Any of them that will properly atomize the oil and distribute the flame are satisfactory. The two extremes of the scale of desirability are, on the one hand, the burner which, by the use of a slight excess of atomizing steam, gives steady and reliable service, and, on the other hand, the one where the steam passages are reduced to just the amount necessary for atomization, but which must be watched a trifle more carefully on account of plugging up at times with dirt or carbonized oil.

The steam consumption of the former type is not over 4 per cent of the boiler output, and of the latter slightly less.

The most important instrument for oil burning is a window in the roof, through which the boiler-room engineer can see the top of the stack. Smoke, of course, is always a loss, and when firing up cold boilers cannot be avoided. A more serious loss, however, is excess of air, and this can occur with a perfectly clear stack. The best firing will be done by increasing the amount of air until the smoke stops and then cutting it down slowly until a slight haze of smoke shows.

In the larger plants, of course, more scientific methods are available. Steam-flow meters, venturi meters on unit groups of boilers, and the customary stack instruments are used and pay better returns than perhaps any other part of the investment, provided always that the information obtained from them is used for the immediate correction of any deviation from normal conditions.

3 How Can Soft Coal Be Burned Without Smoke in Marine Boilers?

The avoidance of smoke would decrease the radius of visibility of our ocean carriers by many miles and greatly reduce their liability to attack by submarines. If efficiency is improved incidentally it means much more than the mere coal saving.

ALBERT A. CARY. It has been repeatedly asked how to avoid the production of smoke from the steam-generating equipments of transatlantic vessels under the present conditions of submarine menace. It is an extremely vital question which has seemed to evade its answer most adroitly. After having studied this matter carefully for some time, in the light of almost 30 years' experience with most of the special furnaces and smoke-suppressing devices in this country, and many of those abroad, I can state without qualification that this trouble *can* be met, practically and satisfactorily, provided our marine friends are willing to meet us half way in their new constructions and make a compromise between old, time-honored marine-boiler practice and successful land practice.

Although an innovation, this does not mean drastic changes from their present form of steam-generating equipment; it simply means getting sufficiently away from the furnace practice long followed which has caused the submarine-signaling smoke nuisance.

The question submitted in this topical discussion is very simple and direct, and equally direct answers might be given

by stating: suppress the fires in the furnace by firing in such small quantities as to prevent the emission of smoke; or, secure *complete* combustion in the furnaces and combustion chambers. The first-named method, of course, must result in a serious loss of the vessel's speed. The second method gives the only wholly rational solution of the trouble.

The average types of marine boilers with their present form of attached furnaces make it well-nigh impossible to secure complete combustion within the furnace in such a way as to suppress smoke without sacrificing efficiency. On the other hand, it is possible to make rational changes in the steam-generating equipments for *new* ships so as not only to suppress the smoke nuisance, but to carry vessels through the danger zone at their highest speed.

To accomplish this highly desirable end by working along the lines of the latest successful developments in land practice, we shall probably require 4 ft. more headroom, in which to place the boilers, but even should 5 ft. be demanded, the tremendous advantage gained would far offset any objections that could be raised to this innovation in the marine-boiler practice of the past.

Example of a Stationary Installation Applicable to Marine Practice

To illustrate, I will refer to an equipment for stationary boilers in which I have been interested from a purely professional standpoint, and which can be practically adapted to marine service in new vessels to secure high rates of coal consumption without producing smoke.

Eighteen stokers have been operating 500-hp. boilers 24 hours per day continuously for two years, at 50 per cent above their rating, with average grades of eastern bituminous coal of no better quality than is used by transatlantic ships. They have been continuously burning from 42 to 45 lb. of coal per sq. ft. of grate per hour, with a clean smokeless chimney and have shown an easy forcing capacity when over 60 lb. of this eastern bituminous coal is burned per hour per sq. ft. of grate.

The coal is fed from the hopper to the fuel bed in a steady flow in such manner as to avoid the trouble usually following its coke formation and the troublesome caking, and then it is moved along the grate automatically so as to constantly drop its ash directly down to the grate surface where the cool entering air keeps the temperature of the ash below its fusing point, thereby avoiding the formation of obstructing clinker.

The resulting ash is dumped into an ash-sealed pit where it is water cooled and an automatic ash-removing device carries it forward into the front ashpit without disturbing the ash seal and without disturbing the draft conditions of the furnace.

The deep fuel bed is always kept in an open porous condition over its entire surface like a huge sponge, thus requiring a light air-blast pressure, seldom exceeding 1-in. water pressure and allowing each stoker to be operated with an individual disk fan (requiring but little power to operate) instead of the usual heavy steel-plate, forced blast fan with its voluminous air ducts. The result is not only a saving in power required for operation but also a material saving in space requirements.

With the clinkering trouble in firebed, side and bridge walls thus avoided, hand cleaning of the firebed is almost entirely done away with while the firebed is easily kept level and of uniform thickness by an arrangement of the automatic-feed device.

Adjustment of the rate of coal feed is quickly and easily changed (along with the speed of the fan) and thus, with the free-burning firebed conditions existing, a jump from low to high steaming capacity in the boiler is obtained in a very few minutes.

With such exceptional fuel-burning conditions under marine boilers, the production of smoke would be prevented by securing practically complete combustion in the furnace, and the highest steaming capacity of the boiler obtained to take the vessels through the danger zone at high speed.

With the coal supplied to the furnace by simple conveying apparatus and with ash delivered from the ashpit automatically by the stoker and conveyed overboard automatically, hand manipulation can be almost entirely done away with and a happy solution secured of the present difficulty in getting the greatly needed expert firemen.

Osborn Monnett.[1] As to whether soft coal can be burned without smoke in marine boilers, there can be but one answer: Yes. As a purely engineering problem it is feasible. Of the methods tried for this work the underfeed principle has been best adapted. With this method the headroom and ashpit facilities may be cut to a minimum and the auxiliary machinery required is comparable to that ordinarily used for forced draft hand-fired furnaces. Furthermore, this principle of burning soft coal is well adapted to the character of the load (variable speed, etc.) and handles to good advantage the class of coal customarily used for marine purposes on our eastern seaboard. Theoretically, all points are in its favor.

Moreover, considerable practical experience has been gained with underfeed stokers in marine work in the past ten years. A number of marine installations are operating successfully today, among which might be mentioned the following: steamer *Sprague*—6 Scotch marine boilers—12 stokers; tug *Perfection*—1 marine firebox boiler—1 stoker; tug *Mollie Spencer*—1 marine firebox boiler—1 stoker; dredge *Wm. O'Connell*—2 double-end Scotch marines—8 stokers; steamer *Gamma*—6 tubular boilers—6 stokers; dredge *Hecla*—2 Scotch marine boilers—2 stokers; Ward Engineering Co. steamers—2 Ward marine water boilers—4 stokers; Holland-America Line steamer, *Frederick VIII*—8 Yarrow boilers—16 stokers.

These installations, all of the Jones underfeed type, cover a wide variation of marine service from dredges and river steamers to transatlantic liners, and all types of boilers, including Scotch marine, marine firebox and water-tube boilers, of both straight- and bent-tube varieties.

The problem is not so much a mechanical one as it is one of the human element. Put one man (fourth engineer) who is familiar with this type of equipment on duty on each watch and no difficulty need be experienced. The necessary men could be recruited from the large number of power plants in this country now using underfeeds.

As far as hand firing with Scotch marine boilers is concerned, experience has been discouraging. The writer once succeeded in operating smokelessly a steamer so equipped, without any apparatus, simply by changing alternate fires. It happened that the boilers, two in number, were equipped each with three corrugated furnaces, all discharging into a common combustion chamber. The volatile matter from the fresh fire was consumed by the hot gases from the other two fires. With two furnaces the results would have been less satisfactory, and with separate combustion chambers (a common construction) impossible.

The idea in hand-fired furnaces has been to mix the gases, after they pass the bridge wall and while they are at a high temperature, with an auxiliary supply of air, and so accomplish complete combustion. Experiments have been made in

[1]American Radiator Company, Chicago.

Chicago harbor with brick arches, baffles and other constructions calculated to do this, but the small space available in the Scotch marine boiler has prevented satisfactory results. In fact, the writer's experience with forced draft, induced draft, special air admission, preheated air, panel doors, steam jets, induction tubes, stack blowers, hollow bridge walls, etc., etc., has led to the conclusion, more strongly than ever, that some type of underfeed stoker is the logical answer to the Scotch marine boiler problem.

In water-tube boiler construction, such as has been adopted by the Emergency Fleet Corporation, there is more opportunity to do things and it is not unreasonable to hope that a satisfactory hand-fired furnace for these units will be developed.

H. B. OATLEY.[1] At or above the normal rate of operation, the burning of soft coal with the complete elimination of smoke, if not impossible, is an extremely difficult problem. A great deal, however, can be done to approach this desired state of perfection.

Conditions which will secure proper combustion may, of course, be provided on new ships and we are led to expect well-designed boilers, furnaces and uptakes on the ships now building. On existing vessels, however, unfavorable conditions may exist with respect to the proportions of air openings through the grates, volume of furnaces and combustion chambers, area for gases through fire tubes and around water tubes, and finally areas of uptake, breeching and stacks. The means for heating the air supply, in forced-draft installations, may have been inadequately proportioned. It is very desirable—in fact it is imperative—to improve these conditions to the greatest extent possible. It is probable that to correct these conditions, so far as the boiler itself is concerned, would be prohibitive on account of delay and expense in installing new boilers. Grates, uptakes and the air-admission channels, however, may be corrected in a short time and at a reasonable cost.

The personnel in the fireroom is a prime factor in the success or failure of any boiler plant. It must be realized that the rapid expansion of our shipping requires recruiting of men with little or no experience in the fireroom. Great effort and expense are justified in giving all possible training to the fireroom crews.

Steam economy is a big factor in the elimination of smoke, because it results in reduction in the amount of fuel used and reduction in the rate of combustion.

Improvement in marine steam plants, considering the present use of triple-expansion engines, turbines, feedwater heaters, well-lagged steam pipes, etc., presents fewer opportunities than in other lines. In the use of superheated steam, however, marine power plants in this country are considerably behind the merchant marine in other leading countries. There are opportunities for reducing the fuel used by upward of 12 per cent, and naturally a *greater* percentage reduction in the smoke produced. This is particularly applicable to existing ships as the necessary installations may be made at moderate cost during an overhauling. A reduction in the fuel used would make suitable many plants that have restricted areas through which the gases pass, and permit of greatly improved combustion.

For existing ships there is a greater reduction in smoke to be expected by the more economical use of steam, at least under present conditions, than by any other means.

M. C. M. HATCH.[2] Soft coal can be burned without smoke in marine, as in all other boilers and furnaces, up to the point at which the furnace volume becomes too small to allow for proper air-mixing and combustion space for the volatile hydrocarbons contained in the coal. This varies, of course, with designs, but the limits imposed by the unavoidable restrictions in designs for marine work make it most difficult to force high ratings from such boilers, under hand-fired conditions, without smoke.

The earlier in the combustion process that intimate mixture of air and volatile gases occurs and the smaller the volume of excess air necessary to complete combustion and hold down furnace temperature to workable limits, the greater is the amount of coal that can be fired (and consumed) per unit of time per unit of furnace volume without smoke, and hence the higher the rating which the boiler can deliver.

Coal, in pulverized form, induces the desirable intimate mixture of gases and air very early in the process of combustion and it has been shown, as it is logical to expect from the very nature of its burning, that less total air is needed per unit weight of fuel, than with hand firing. In support of this it has been repeatedly shown, in locomotive and stationary practice, that smoky coals can be burned smokelessly at very much higher rates of combustion than possible under any other conditions. The logic of the case and the facts in other services all point to the conclusion that soft coal, in pulverized form, can be burned in marine-boiler furnaces at much higher rates than will ever be possible to attain with hand firing, and that smoke will be eliminated or very materially reduced. To just what point the furnaces could be forced, in any individual instance, depends, very largely, on their fundamental design and volume, but in any case the smoke thrown would certainly be much reduced by the use of pulverized coal.

HENRY KREISINGER. Perhaps the best way of burning soft coal in marine boilers without smoke is to do away with hand-fired furnaces and install mechanical stokers or pulverized coal.

For smokeless combustion, two requirements are essential: first, the volatile matter must be distilled at a uniform rate; second, the distillation must take place in the presence of large amounts of free oxygen so that the volatile matter can be burned before the smoke is formed. These requirements are not satisfied in the hand-fired furnace. On the other hand, most of the mechanical stokers, as well as the powdered-coal furnaces, furnish means of satisfying these two requirements.

In the hand-fired furnace the distillation is rapid immediately after firing and most of the volatile matter is distilled during the first half of the firing cycle. It is difficult to supply enough air during this period of rapid distillation without having too high an excess of air after the distillation has been nearly completed, unless the air supply is varied in such a way that it is at all times nearly proportional to the amount of volatile matter that is being distilled. Such variation of air would require close attention on the part of the fireman and is hardly practicable aboard a ship where firemen are changed frequently.

In the hand-fired furnace the distillation of the volatile matter takes place in the absence of oxygen, and the volatile matter is broken down by heat into soot and light hydrocarbons. The fresh coal is placed on top of the fire and moves down towards the grate. The air is fed from below through the fuel bed in the opposite direction to that of the coal. Before the air reaches the distillation zone at the surface of the fire, all the oxygen is used up in burning the carbon in the lower

[1] Lieutenant, U. S. Naval Volunteers; Chief Engineer, Locomotive Superheater Co., New York. Mem.Am.Soc.M.E.

[2] Locomotive Pulverized Fuel Company, New York.

layers of the fuel bed. The sooty smoke is formed at the surface of the fuel bed because there is no oxygen to burn the volatile combustible, and because the latter is subjected to high temperature; it is not formed by sudden cooling.

Most mechanical stokers feed the coal into the furnace at a uniform rate so that the volatile matter is distilled also at a uniform rate. It is therefore comparatively easy to adjust a uniform supply of air to the volatile matter to insure its complete combustion without a too high excess of air.

Furthermore, with most of the mechanical stokers the air and the coal are fed into the furnace in the same direction, so that at the point where distillation takes place the air contains nearly 20 per cent oxygen. On account of this large percentage of free oxygen the combustion of the volatile matter proceeds to completion without deposition of soot.

What has been said about the mechanical stoker is true of the pulverized-coal burner. The coal and air are fed into the furnace together at a uniform rate so that the two can be easily adjusted to the proper proportion. The volatile matter is distilled from the small particles of coal while the latter are surrounded with an atmosphere containing nearly 20 per cent of oxygen.

With the pulverized coal a large part of the mixing of the combustible with the air can be done outside of the furnace. Thus the combustion space of the furnace needs to do only the burning and little mixing. Something similar to this is being done in the gasoline engine. Only the burning is done in the combustion chamber, the mixing being done in the carburetor. High temperature is of lesser importance. Complete combustion can be had in the gas-engine cylinder in spite of the fact that the walls of the combustion chamber are water-cooled.

Carrying on the mixing outside of the furnace deserves full consideration in the case of marine boilers, because the restriction of space on board ship makes large combustion chambers prohibitive.

HAYLETT O'NEILL[1] (Oral). For the past two months I have been running tests of marine boilers using pulverized coal at New Haven, Conn. We have been able to burn this fuel without smoke, and have obtained just as much speed and power as with the regular oil-burning equipment aboard this ship. The boilers are of the Normand express type, with a very small furnace particularly unsuited to such fuel as powdered coal. I believe that the future will see much work done in marine practice in the way of substituting coal for oil, inasmuch as the fuel in the form of coal will cost about one-half or even one-third what the oil will cost.

[On board the boat mentioned by Mr. O'Neill a mixture of powdered coal and fuel oil is used—32 per cent of the mixture being coal, 95 per cent of which passes through a 200-mesh screen. The coal remains suspended for many days without settling so seriously as to interfere with operation. The usual mechanical Navy burner is used without alteration. The volumetric heat value of the mixture is about the same as that of the straight oil with an average good coal because of the greater density of the coal. If this mixture of oil and coal proves to be successful, it would, of course, if widely applied, go a long way toward relieving the consumption burden now imposed on our fuel-oil resources.—EDITOR.]

JOHN S. SCHUMAKER[2] (Oral). In the Assabet mills, Maynard, Mass., about twenty-one Manning type boilers were used to burn New River coal. The furnaces of these boilers have no firebrick, and, ordinarily, considerable smoke was formed in the combustion of the coal. It may be interesting to know that this trouble was practically eliminated by the introduction of air above the fire. The fire doors were at first left on the latch, that is, left open a trifle, and later, as a permanent arrangement, 5-in. openings were introduced in each door. These openings, when properly regulated, greatly reduced the smoke.

[1] Larchmont, N. Y.

[2] S. D. Warren & Co., Cumberland Mills, Me. Assoc.-Mem.Am.Soc. M.E.

4 What Are the Possibilities in the Direction of the Utilization of Anthracite Wastes?

What success have you had in burning anthracite slack or culm? Do you mix it with soft coal and in what proportions? What sort of grate do you use and what is your practice with regard to thickness of fire, draft, rate of combustion? Can the mixture be burned in a stoker?

JOHN E. MUHLFELD.[1] The indications are that during the current coal year (April 1, 1918, to March 31, 1919), about 80,000,000 tons of anthracite coal will be mined for distribution as compared with 77,000,000 tons during the past year, of which latter amount about 5,500,000 tons were exported. Of this year's output probably 25,000,000 tons will be steam sizes, leaving 55,000,000 tons for domestic and specialized uses.

New England alone will require about 13,000,000 tons of anthracite, exclusive of steam sizes, whereas, according to the Anthracite Committee of the United States Fuel Administration, its allotment is now placed at about 10,500,000 tons.

The exclusion of almost one-half of the 48 states in the Union from participation in this year's anthracite-coal production, and a shortage of 25,000 to 50,000 men from the number normally engaged in the anthracite mining field, in combination with the lack of water and rail transportation facilities, establishes the immediate necessity for reclaiming and utilizing every ton of anthracite silt, slush and culm that is now being produced or which is stored above ground.

CONSUMPTION OF ANTHRACITE AT THE MINES

As about one ton of anthracite coal is now consumed at the mine in the production of steam to mine each 8 or 9 tons produced, the logical use to which these waste sizes should be put is in the production of power, heat and light at the mines. By this procedure useful by-products of from 11,000 to 12,000 B.t.u. heat value per pound—which are now being wasted by diversion to streams, back filling into abandoned mines, or by dumping in culm banks, and which represent about 10 per cent of the total tonnage mined—can be made to release from 85 to 90 per cent of the commercial-size anthracite that is now being consumed for mine steam generation for use in locomotives and at industrial plants located nearest the points of production. In other words, in the production of 80,000,000

[1] Pres., Locomotive Pulverized Fuel Co., New York. Mem. Am.Soc.M.E.

tons of domestic and steam anthracite during the current coal year, the reclamation and utilization of the silt, slush and culm by-product for mine-operation purposes would release about 8,000,000 additional tons of steam-size anthracite that could be diverted to commercial use, and more than make up the shortage in supply.

It should be remembered that the only cost for this additional tonnage would be the means required for its reclamation and for its preparation and use, as the labor, material and plant for mining are now being employed in its production.

By pulverizing this by-product anthracite and burning it in suspension, as oil or gas is burned, it can be used for stationary-boiler purposes without the admixture of any other fuel, and easily produce from 100 to 150 per cent of the rated boiler capacity. For locomotives it can be utilized by mixing 60 per cent with 40 per cent of any gas or soft bituminous slack or screenings available, then pulverizing, and burning it in suspension.

Burning Anthracite in Suspension

The ideal means for preparing and disbursing this fuel would be to install preparation plants at the collieries, from which both locomotives and stationary power plants could be supplied, thereby relieving railway facilities, locomotives and cars otherwise required for its transportation. Such utilization would also avoid the use of cars and vessels for hauling fuel with a relatively high percentage of non-combustible. Every ton of anthracite to be shipped by rail or water for any considerable distance should have not more than 10 per cent of ash and impurities and be of the best quality possible to conserve the already overburdened transportation facilities.

Here are millions of tons of anthracite coal that average higher in heat value than the average run-of-mine bituminous coal in Michigan, Illinois, Iowa, Missouri, Kansas, Oklahoma, Texas and other points of the West from which about one-third of the bituminous coal supply is now being produced, and for which anthracite by-product, man and machine power, mining equipment and supplies are being used daily in its production, with the resultant waste of output for want of installation of proper means for its effective and economical utilization.

These by-products can be reclaimed and utilized for what it now costs to place them on the dump or to pump them back into the mines, and by proper preparation and burning in suspension—as with oil or gas—there will be the additional power-plant advantages of reduction of man power, greater boiler capacity, better control of steam pressure, elimination of banked fires, decreased ashpit handling, elimination of fire cleaning and of metal work in the furnace, better combustion, and lower fuel losses.

Furthermore, with the relatively low volatile nature of these waste by-products, which require a temperature of between 550 and 600 deg. fahr. to produce combustion, there will be no difficulty in handling or storing fuel after pulverized, in any manner desired from the standpoint of loss of heat value or spontaneous combustion.

At present the bituminous coal supply is only running at from 75 to 80 per cent of production, due largely to shortage of from 10 to 15 per cent in the car supply. As the anthracite supply of commercial steam sizes is also inadequate, unless some means is immediately adopted to provide for the reclamation and utilization of useful mining by-products, we can expect the same hardships on the people and the manufacturing industries as obtained last winter.

W. S. Hachita.[1] The anthracite industry is located in the northeastern part of the state of Pennsylvania. The area underlaid with anthracite is approximately 800 square miles. Roughly the field is divided into four parts: namely, the northern field, comprising the Carbondale, Scranton, Wilkes-Barre and Nanticoke districts; the northern middle field, or Hazleton district; the southern middle field, including Mahanoy City, Shenandoah, Mt. Carmel and Shamokin; and the southern field, consisting of Lansford, Pottsville and Tremont districts.

In preparing anthracite, there are two kinds of waste produced: first, fine material, the largest pieces of which are no bigger than 3/32 in., which is so fine that, heretofore, it has been considered unmarketable; second, rock refuse. The latter material has been picked out during the process of preparation. The production of culm at present is approximately 7½ per cent of the total output.

Culm Production in Tons

The average culm production from the beginning of the industry to the present time (1820-1918) is about 15 per cent of the tonnage mined. According to the statistics, the anthracite mined and shipped from 1820 to January 1, 1918, amounts to 2,332,673,250 tons, so that the amount of culm produced during the same period is 349,901,000 tons. Out of this, about 50 per cent has been taken into the mines to support the roof and washed away, leaving 174,950,000 tons available above ground in the whole anthracite field.

The rock refuse, which consists of slate and bony coal, amounts to approximately 10 per cent of the output, or about 233,267,000 tons. The slate which occurs in anthracite measures is entirely unlike that used in roofs, sidewalks, etc. On the other hand, it contains from 28 to 48 per cent of combustible material, while the bony material contains from 45 to 70 per cent of combustible. The rock banks, composed of slate and bone, contain at least 50 per cent of the heat in commercial anthracite. At the present, rock refuse is not utilized as fuel in the anthracite field.

The fine material which is locally known as culm slush, or silt, contains 70 to 85 per cent of combustible material. It is therefore a good fuel, provided proper means of burning it can be used. During the last sixty years, a large amount of experimenting has been done with a view of utilizing this material.

A thorough research, relative to the utilization of anthracite culm was made by the Lehigh Valley Coal Co. in 1913, at the Spring Brook boiler plant, near Hazleton, Pa.

For this purpose there were arranged a battery of four cylindrical boilers, 33 in. in diameter and 30 ft. long; one smoke stack, 33 in. in diameter and 33 ft. high; a total grate area of 132 sq. ft., having air space of 19.8 sq. ft., or 15 per cent of the total area.

The fuel was burned under forced draft of ½-in. water gage. The mixture consisted of culm and bituminous coal. In the test, the fuel was fired in alternate layers of bituminous coal and culm, also a thorough mixture of both fuels in various proportions. It was soon found that a thorough mixture of culm with bituminous coal was the better method and this method was therefore used throughout the tests.

Mixtures of Soft Coal and Culm

The first series of tests consisted of 30, 50, and 70 per cent of run-of-mine coking coal mixed with 70, 50 and 30 per

[1] Lehigh Valley Coal Co.

cent of culm from the Hazleton Shaft Colliery of The Lehigh Valley Coal Co. The second set of tests consisted of a mixture containing pulverized bituminous coal. The biggest pieces of soft coal in the mixture were not larger than 2 in. in diameter. Both fuels were thoroughly mixed in the above proportions by the use of shovels, and fired. The result of these tests shows that, in every case, the pulverized bituminous coal produced the better results.

The non-coking bituminous coal was also tried but it did not produce the same results as those produced by the coking coal. The reason why the coking coal is better adapted to mix with the culm lies in the fact that the coking coal fuses at a comparatively low temperature and the fusion takes up the particles of culm, forming a homogeneous mass of fuel which burns uniformly. The results of these tests show that a mixture consisting of 30 per cent of culm and 70 per cent of coking bituminous coal produced a water evaporation equal to that evaporated by the straight bituminous coal. It was also noticed that the mixture was easier to burn than soft coal alone. This is due to the fact that when soft coal alone is burned, the fuel bed becomes a hard, coked mass requiring considerable poking to effect complete combustion, whereas in the case of the mixture, the coked fuel is more easily handled by the fireman. It was also noticed that the fuel produced little smoke.

In September, 1917, E. E. Loomis, president of the Lehigh Valley Railroad Co., was informed by F. M. Chase, vice-president and general manager of the same company, about the formula of the mixed fuel with the view of burning the mixture on stoker engines. It was then decided to try it on big freight locomotives running between Hazleton and Lehighton, a distance of 26 miles. In this test, the fuel consisted of 30 per cent culm and 70 per cent of stoker coal or slack. The train was made up of 50 cars of coal hauled from Hazleton to Lehighton and returned to Hazleton with 65 empty cars. There was no trouble experienced in the test and later evaporation tests made on locomotives using the mixed fuel and straight bituminous coal.

More Steam with Mixed Fuels

The results of these evaporation tests showed that the mixed fuel produced approximately 30 per cent more steam than straight bituminous coal although the calorific power of the latter was considerably greater than that of the mixed fuel. This is due to the fact that the complete combustion of the hydrocarbon is possible in the mixed fuel, whereas, in burning straight bituminous coal, the greater part of these valuable hydrocarbons are lost as smoke.

B. S. Murphy. Our plant was designed to use the small sizes of anthracite coals and under normal conditions we have no difficulty in doing so even with the No. 4 or dust. The increase in the impurities with a relative decrease in calorific value due to colliery methods, such as mining, failure to wash in the larger sizes, such as No. 1, the large amount of shale and pebbles in the so-called river coals, dredged coals, etc., has placed a different aspect on the problem; but one that can be solved successfully for such plants as are now equipped or will procure the necessary equipment.

The coal used varies from straight No. 1 buckwheat to No. 3 and No. 4, the latter, or dust, using the recommended A.S.M.E. scale, being that passing through a 3/32-in. opening. Our so-called No. 3 has from 45 to 60 per cent dust and the No. 4 over 60 per cent and up to 85 per cent through 3/32-in. screen.

Influence of Size of Coal

It is most desirable from both an economic and operating standpoint to adhere to one size of coal for as long time periods as possible. It is impossible to maintain good economy when the run of coal for the boilers changes continually from the smaller to the larger size and back again, for an entirely different method of manipulation is necessary. On the other hand, if the fuel is a well-mi ed one, say one as follows: 15 per cent of No. 1, 20 per cent of No. 2, 40 per cent of No. 3 and 25 per cent of No. 4, and remains as such, it can be handled well and in fact is easier to handle than the No. 3 for poor firemen.

The reason for the mixture of bituminous coal with the anthracite is twofold: (*a*) to act as a binder and (*b*) to increase the calorific value. With the large size, No. 1 buckwheat, our practice is to add no soft coal. Here we find that the soft coal is a detriment, forms clinker with the impurities and makes the firing more difficult.

With the small sizes the primary function with the good coals—11,500 B.t.u. to 12,000 B.t.u.—is to act as a binder to hold the fire on the grates, and with the poor coals to increase the calorific value as well.

The amount necessary to bind the fuel varies from 5 to 10 per cent, say 7.5 per cent as a mean; this again will depend, however, on the quantity of the No. 4 size. The smaller the coal particles the greater the amount of bituminous required, until with the straight No. 4, say 80 per cent, from 15 to 20 per cent should be used.

Another use for the bituminous coal is the "building of bottoms" in the fire and the repairing of holes. This is especially true with the untrained firemen, and our practice is to have a small bunker of bituminous on the fireroom level where the men can get a few scoopfuls from time to time for this purpose.

Bituminous Mixing

It is of the utmost importance to have the bituminous well mixed with the anthracite, for the better the mixture the less required and the better the economy. In small plants where the coal is brought to the fires in barrows it should be turned in on the floor similar to mixing concrete.

Our practice at the present is crude and consequently does not give the best results. The coal is delivered in hopper-bottom cars, a predetermined number of buckets of bituminous is added from a storage pile on top of the car, by means of a locomotive crane. The coal is then dumped on conveying belts delivering the mixture to a crusher and thence to the overhead bunkers. In the summer this method works fairly well, but in the winter, with the coal frozen, the soft coal may be delivered to the bunkers some 30 or 40 min. before the coal in the car is all unloaded, because the pockets thaw first and the soft coal goes through a long while before the ends of the car thaw enough to flow. This results in uneven distribution about the boilers, some chutes having far too much soft and others not enough. Here again the emergency bunkers on the fireroom level come into play.

An element that enters into hand firing of small anthracite sizes is the vast formation of soot or flue ashes. It is necessary to carry considerable draft and the result is that some of the combustion is similar to that of powdered fuel; it never reaches the grates after leaving the fireman's shovel, it either ignites and burns in the air or is brought over to the rear connections in the form of coke. The greater the rating, the larger the soot deposits due to the greater draft neces-

sary; but even working the boilers at light loads, a very large amount is formed. Our boilers were designed with this in view and have a large space in back of the bridge wall to allow this soot to accumulate, and soot pipes extending down into the ash cellar to allow it to run directly into the ash cars; our economizers are also equipped with soot pipes for this purpose. With the No. 4 coal and insufficient soft coal in the mixture, we will build up soot four or five tubes high between cleanings of soot hoppers, or in six hours.

To give an idea of the magnitude of this, we have had months when the weight of the soot removed was 10 per cent of the weight of the coal fired; this is exceptional, and it should be from 6 to 7 per cent. It may be of interest to note that at times an analysis of the soot shows a slightly higher calorific value than the coal it was made from, due to the fact that the soot is principally coked coal without impurities. We have attempted to burn this but with no success. However, if a small briquetting plant with a cheap binder were available, it could be done successfully. The soot formed by the stoker is naturally but a small percentage of that in the hand-fired boiler.

The gates are the inclined dumping type, with an area of 190 sq. ft. per boiler of 900 hp. The air spaces are 20 per cent with one and 9 per cent with the other.

Thickness of Fire

Our practice is to carry as thin a fire as possible without danger of blowing through and forming holes. The thickness of fire hinges on the formation of a good bottom after cleaning, say about 3 to 5 in. thick, and then building up as slowly as possible. We clean before the service hour and start cleaning again as soon as the peak is over, some two hours if the fires will stand that long. The thickness of the fires at the time of cleaning is problematic, depending on the load carried and the coal; we have had them from 20 to 24 in. or even heavier, but 16 to 18 in. will be nearly an average.

The amount of draft available is of the utmost importance as it is impossible to use the small sizes without a high ashpit pressure. At our Terminal Building in New York we can carry the normal load, somewhat below boiler rating, with natural draft, but here, on account of the great height of the stack, about 320 ft. above the top of the grate, we have an unusual condition: when the boilers are brought to rating the natural draft has to be augmented by blowers. At the Jersey City Power Station we use from 2½ to 3-in. water gage between loads and from 4 to 7 in. during the peaks, depending upon load and condition of fire.

The rate of combustion varies with the load and coal. During our peak hours, with poor coal we burn from 40 to 60 lb. per sq. ft. per grate per hr., while for the whole 24 hr. the rate will be from 20 to 25 lb.

We have but one stoker installed at the present, a Coxe (chain grate), but we are now equipping all of our hand-fired boilers with this type of stoker.

Handling Frozen Coal of Fine Grades

An important consideration in the use of culm for fuel is the thawing of coal during the winter months if the coal is delivered to the plant in cars. On account of its compactness the moisture freezes to a hardness equal to that of lean cinder concrete and a dull-point chisel is necessary to cut it. If a thawing house is not available, special provisions will have to be made. Our practice is to use from 8 to 12 thawing pipes per car, 1¼-in. extra heavy pipe fittings with cap and tee at upper end, a drive point at the lower end and the lower portion of the pipe above the drive point perforated with a large number of small holes. The pipes are entered in the top of the pile in the car and after the thawing begins are driven down from time to time with a wooden maul. The pipes connected in series are fed with 140-lb. superheated steam. It requires from two to six hours for this and then the car is brought over the unloading hopper. The car hopper will be iced so badly that it also will have to be thawed, especially the operating mechanism. To do this we use portable nozzles made up of three 1-in. pipes clamped together with a common steam connection to a rubber steam hose, the outlets of the pipes staggered to make an equilateral triangle and bent at right angles to the body of the pipe. This will thaw the car-door mechanism within a few minutes, so that the doors can then be opened. The worst frost will be found here on account of the drainage accumulation at the low parts, but about ten minutes with two nozzles will start the coal running in the worst car, opening a hole to the top of the car and allowing the coal thawed by the top pipes to run out. It must be borne in mind, however, that this will require a large amount of steam; we find this equivalent to 10 tons of coal per 24-hr. day for from 12 to 18 cars unloaded. It is also necessary to have quite a gang of men working in the car; we use from 4 to 8 to the car because considerable picking is necessary where the coal adheres to the metal sides of the car.

Storage of Anthracite Coal

We attempt to keep from 13,000 to 14,000 tons of small-size anthracite in storage at all times and find that there is no deterioration after at least two years' storage. The greater part of our coal is stored outdoors and this does not change at all. Some 2,600 tons have been stored for one year in overhead storage bunkers where the summer temperature becomes very high. When we had occasion to use it last winter, it had naturally become very dry and powdery and formed somewhat more soot than the new coal; otherwise it gave satisfaction.

W. G. Diman.[1] We have at the plant of the Amoskeag Manufacturing Company 185 Manning boilers of which 169 are running today; all boilers are fitted with Jones underfeed stokers. About two years ago we began to get small quantities of anthracite screenings and refuse; the amount has been increasing until we are now burning hard coal of No. 2, No. 3 and bird's-eye sizes straight under 135 boilers, and hard coal mixed with a small percentage of soft coal under the other boilers.

When we began to receive the hard coal we experimented with various mixtures, but finally used the fuel straight on each to get comparisons of the various grades to assist us in buying. We found that with the regular installation of the Jones stoker the coal was pushed over on to the dead plates and lay idle there with no chance for air to mix and consume the coal. When the buckwheat was hot, it acted like sand and the tuyere blocks on the side of the retorts had a tendency to blow the coal over to the side and pile it up. In order to make an even fire and to get better distribution of air for burning, we put in pin-hole dead plates with about 270 ¼-in. holes, or a total increased air area of about 14 in. The plates were not faced off but were rough castings, which allowed considerably more air to get into the fire. I think still better results would be obtained if we cut off some of the air spaces in the tuyere blocks and added air space in the dead plates. This would

[1] Supt. of Power, Amoskeag Mfg. Co., Manchester, N. H.

reduce the open spaces in the bed caused by the tuyeres' blowing away the coal and produce a more even fire. Some of the coal drops into the pits, which have to be cleaned out to prevent their burning and forming explosive gases.

We carry a light fire, about 6 in. to 8 in. thick, which allows the air to get through. About 2 in. water pressure is carried at the tuyere blocks and no draft in the uptake. We burn about 600 lb. of coal per hour or about 26 lb. of coal per sq. ft. of grate. The larger the grate and the easier the fire is run, the better the results.

We have had to run anthracite coal as high as 25 per cent in ash. When doing this we have considerable trouble with the fires and handling the ashes. We find that the more we handle the fires the greater the loss. We cannot get efficient results out of coal containing much more than 20 per cent ash and if we should get coal containing 40 per cent ash it would be useless to us. In view of the transportation problem and freight rates, the place to burn any coal having about 25 to 30 per cent ash is at the mines, where they can equip to burn the specific fuel which is produced.

The following notes show what results we obtained from our tests, all of which ran 12 hours. Each lot received is tested before and during shipment to see if its quality compares favorably with other coal of the same kind.

An average of 20 tests of straight soft coal of different qualities gave an efficiency of 76 per cent with an evaporation from and at 212 deg. per lb. of dry coal of 10.7 lb. The ash averaged 8 per cent. These tests were made without any perforations in the dead plates.

One test of mixture made with two-thirds soft coal and one-third buckwheat gave an efficiency of 74.7 per cent with an evaporation of 9.93 lb. from and at 212 deg. per lb. of dry coal; and the ash averaged 11.4 per cent. This gave a good fire but, of course, required a little more work and attention from the firemen. The load could be easily carried under these conditions.

An average of two tests of mixture made with one-half bank coal and one-half soft coal gave the following results: efficiency, 58.3 per cent, evaporation from and at 212 deg. per lb. of dry coal, 6.97 lb.; ash, 19.73 per cent. This coal was somewhat dirtier than the average and required considerable work from the firemen. We burned about 670 lb. of coal per hour and ran about 93 per cent of the boiler's rating. The results of all our tests with culm prove that it is much below buckwheat and smaller sizes in evaporation and the only way to get it on a basis with buckwheat is to increase the soft coal percentage, which of course increases the mixture price. It would take three parts soft to two parts culm to equal two parts buckwheat and one soft.

An average of two tests made with a mixture of two-thirds buckwheat and one-third soft coal gave an efficiency of 66.2 per cent with an evaporation of 7.96 lb. of water from and at 212 deg. per lb. of dry coal; ash, 14.83 per cent. These two tests were made on a little better grade of bank coal. We burned 676 lb. of coal per hour, and obtained 95.1 per cent of the builder's rating. The boilers are of 150 hp. each. We used a draft in the tuyere blocks of 1.59 in. and 0.07 in. in the uptake. When burning this mixture, the fire burns well but needs close attention. A light fire must be carried.

An average of eleven tests of anthracite refuse, which includes bank coal and culm (no soft coal used), gave the following results: efficiency 55.7 per cent, evaporation from and at 212 deg. per lb. of dry coal, 6.75 lb.; ash averaged 17.8 per cent. We consumed 628 lb. of coal per hour, obtained an average of 78.4 per cent of the builder's rating and used 1.86 in. of water pressure at the tuyeres. This was an experimental mixture made to see what it would do.

An average of seven tests with prepared anthracite screenings of No. 2 and No. 3 buckwheat and bird's-eye without any soft coal gave the following results: efficiency 59 per cent, evaporation from and at 212 deg. per lb. of dry coal, 7.47 lb.; ash averaged 14.5 per cent. We consumed 742 lb. of coal per hour, obtained 96.7 per cent of the builder's rating and used 1.73 in. of water pressure at the tuyere blocks.

We made one test using one-half culm and one-half buckwheat, which gave an efficiency of 53.2 per cent and obtained an evaporation of 6.13 lb. from and at 212 deg. per lb. of dry coal. The ash averaged 21½ per cent. We consumed 680 lb. of coal per hour and obtained 72 per cent of the builder's rating. To do this we used 1.87 in. draft at the tuyeres. The culm, of course, has a tendency to pull the buckwheat down.

In order to burn anthracite screenings and refuse successfully under our conditions, a Coxe stoker specially built for this grade of coal should be used, or a small amount of soft coal must be mixed in. This mixture must be maintained at all times and the better the mixture the better the results of combustion, for the successful burning depends entirely on the mixture. In our case the coal is dumped in as it comes and we have to take it as it comes. It cannot be burned successfully by having a run of say two hours on hard coal and then a run with a mixture of hard and soft coal. The whole thing is to have a uniform mixture in order to make a steady fire.

Some of the buckwheat clinkers and some of it will break up into smaller pieces, mixing with the fire, which makes it hard to clean. The fire should not be disturbed any more than possible. It is not good judgment to use a slice bar more than is necessary. The fires should be kept medium and the hoe should at all times be able to touch the grate. When hot, this class of coal resembles sand and a hoe can easily move it when necessary and handle the dirt. The lighter the fire, the better are the results. Unless the firemen are watched they tend to carry heavy fires with more draft. With an 8-in. fire we can easily burn 1000 lb. of coal per hour using a 2-in. draft at the tuyeres. The coal should run as even in size as possible.

We can burn screenings successfully if we obtain 20 per cent soft coal. It is more economical to burn straight soft coal than screenings, unless the equipment is installed for the burning of this class of coal. Two years ago last April we ran on soft coal only. We burned that month 10,352 tons of coal as against 13,689 tons of practically hard coal (about 20 per cent of soft coal) this last April. Our steam load this year was 369,512 kw. hours less for the month of April, or about 12 per cent of the total steam load.

If we take hard coal at \$6.25 per ton and soft at \$10 it would make the balance in favor of soft coal, provided the load was the same and we took into consideration the added cost for boiler-house labor and handling ashes.

We recently got a cargo of Dominion coal which apparently is high in volatile. We burned this with buckwheat, a quarter of Dominion soft coal and the rest buckwheat, and we secured the best results that we have ever had. Dominion coal burned straight is poor coal because it clinkers badly, but it has a tendency to mix with anthracite, and the anthracite holds down the volatile elements.

WILLIAM P. FREY.[1] There is only one kind of anthracite waste, and that is material containing 35 per cent or more of incombustible, be it chestnut coal or No. 4 buckwheat. Since

[1] Fuel Engineer, The Lehigh Coal & Navigation Company, Lansford, Pa.

the development of the process of cleaning No. 4 buckwheat (through 1/8-in. round mesh and over 1/16-in. round mesh) and No. 5 buckwheat (through 1/16-in. round mesh) these two products have gained a firm foothold and have come to stay.

No. 3 buckwheat and No. 4 buckwheat are two excellent stoker fuels, if there is a proper stoker installation. No. 5 buckwheat is too light for stoker firing and should be briquetted. To the users of soft coal, hand- or stoker-fired furnaces, I cannot too strongly recommend mixing No. 3 buckwheat or No. 4 buckwheat with their bituminous coal. The curves, Figs. 6 and 7, clearly indicate the possibilities of these mixtures for stoker practice although they pertain only to hand-firing practice. All prices are based on the following scale:

Buckwheat No. 1—$4.10 per long ton f.o.b. mines
Buckwheat No. 2—$3.30 per long ton f.o.b. mines
Buckwheat No. 3—$2.15 per long ton f.o.b. mines
Buckwheat No. 4—$1.25 per long ton f.o.b. mines
Buckwheat No. 5—$1.00 per long ton f.o.b. mines
Uncleaned Silt—$0.65 per long ton f.o.b. mines
Bituminous run of mine—$3.40 per short ton f.o.b. mines.

Firing of Anthracite Buckwheats

Table 7 represents the attempt to tabulate in an easily understandable form the practical operating condition of industrial power plants with highly varying loads. As it was found that a rate of combustion of 25 lb. of dry coal per sq. ft. grate surface was very economical for all sizes, this rate was adhered to as closely as possible by adjusting the speed of the grates and the air supply. As a rough guide for the boiler operatives the blowers have to be set to deliver 20 cu. ft. of air per maximum horsepower. The air control goes hand in hand with the CO_2 recorder readings that read 12 per cent on the average and the stack temperatures which are to be kept below 500 deg. fahr. If the stack temperatures are high, the speed of the grate must be increased, the thickness of the coal fuel bed reduced, the air pressure under the grate lowered, but the rate of combustion maintained as constant as possible. It is very important to understand that the figures given in the column for grate travel in feet per hour are relative to 25 lb. of coal per sq. ft., which means that if the grate runs at 16.2 ft. in case of No. 3 buckwheat, the bed must be carried 6 in. thick. If it is desired to carry only 4 in. the speed of the grate must be increased $6 : 4 = 1.5$ times to keep the same rate of combustion. It has to be understood, too, that 25 lb. per sq. ft. is by no means the highest possible rating. The maximum rating obtainable according to our experience is:

No. 1 Buckwheat—40 lb. per square foot per hour
No. 2 Buckwheat—35 lb. per square foot per hour
No. 3 Buckwheat—30 lb. per square foot per hour
No. 4 Buckwheat—27 lb. per square foot per hour
Uncleaned silt and No. 5 Buckwheat—25 lb. per square foot per hour or less.

These figures apply to a Coxe stoker with 7 per cent air space in the grate.

Good practice will keep the air pressures in the tuyeres as near as possible to 1 in. at the stoker front, graduating down to 0.2 in. at the refuse end of the grate.

The operating equipment includes: automatic feedwater and damper regulators, recorders of steam flow, CO_2, feedwater temperature, steam pressure, and stack draft; draft gages and long-distance thermometers.

Firing of Anthracite and Soft Coal Mixed

Buckwheats No. 3 and 4 are well adapted for mixing with soft coal if they are clean and the mixing is well done. These two conditions are absolutely essential and cannot be emphasized enough. The method of firing need not be changed, although there should be a tendency to fire thin and to damp off. The green coal should be thrown on when the fire is white hot, after leveling, for instance, and then there will be a very pronounced coking effect that will bake the No. 4 buckwheat to a coarsely granulated fuel of about pea-coal size. The fire must be kept loose at all times and will stand very hard blowing.

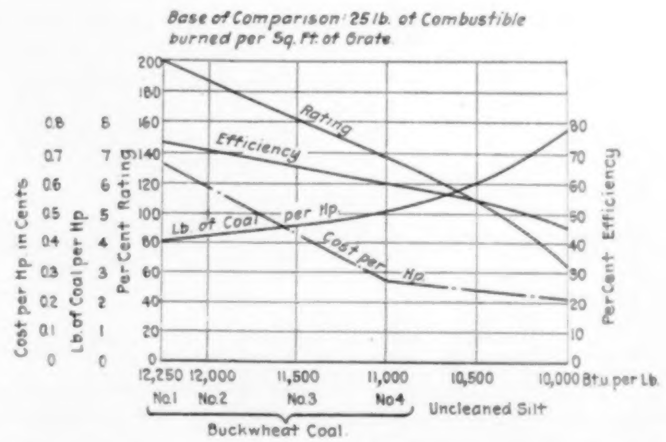

Fig. 6 Performances to be Expected with Various Buckwheat Grades

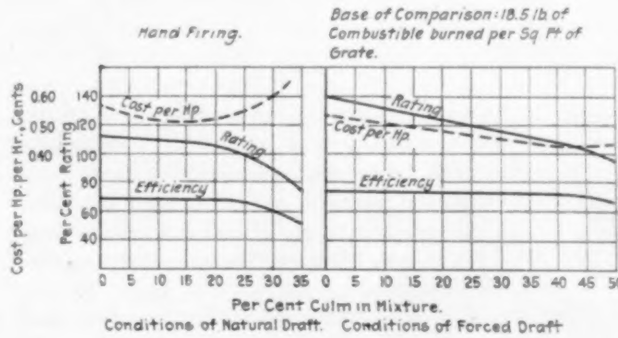

Fig. 7 Performances with Mixtures of No. 4 Buckwheat and Soft Coal, Hand-Fired

Almost any good grade of grate bar is suitable, up to about 3/4-in. openings, provided enough kindling is left on the grate after cleaning to cover the grate. The most gratifying feature of the mixture burning is that it does away with all hard clinkers, which is especially welcome in stoker practice, particularly in underfeed stokers.

The curves in Fig. 7 above show the results obtained in burning soft coal mixed with No. 4 buckwheat in a hand-fired Newburgh fire-tube boiler. The rate of combustion (amount of coal to be shoveled) was kept constant. All coal was crushed to smaller than 1½-in. round mesh.

Briquetting of Anthracite Waste

Either No. 4 buckwheat, or No. 5 buckwheat, or the two mixed, or uncleaned silt, can be briquetted successfully. Anthracite briquetting has passed the stage of experimentation. The binder material is available, and with the concurrence of all concerned, not a pound of anthracite waste should go down

the rivers again. That briquetting is a commercial success is proven by the fact that it raised the price of No. 5 buckwheat from 65 cents to $1, leaving still a small margin of profit, and by the ever-increasing output of our Lansford experimental plant, which shows the following tonnage figures:

1915— 3983 tons
1916—11,194 tons
1917—31,034 tons
Jan. to April 30th, 1918—18,500 tons

TABLE 7 OPERATING RESULTS OF ANTHRACITE BUCKWHEATS

750-HP. MAXIM BOILER—COXE TRAVELING GRATE. AVERAGE STEAM PRESSURE 125 LB.

	No. 1 Buck-wheat	No. 2 Buck-wheat	No. 3 Buck-wheat	No. 4 Buck-wheat	Un-cleaned Silt
Average hp. of test	1500	1395	1200	1010	495
Maximum hp. of test	1750	1600	1400	1100	650
Average per cent rating	200	186	160	134	66
B.t.u. per lb. of dry coal	12250	12000	11500	11000	10000
Combined efficiency of boiler, furnace and grate, per cent	74	70	65	61	45
Equivalent evaporation from and at 212 deg. per lb. of dry coal, lb.	9.35	8.77	7.7	6.9	4.6
Dry coal consumed per hp. per hr, lb.	3.69	3.93	4.48	5.00	7.5
Dry coal per sq. ft. grate surface per hr, lb.	25	25	25	25	25
Boiler hp. per sq. ft. grate surface	6.8	6.36	5.5	4.9	3.3
Grate travel in ft. per hr.	16.6	16.5	16.2	15.2	11.1
Cost per hp. per hour in cents	0.67	0.58	0.43	0.27	0.21

NOTE—Last figures correspond to prices at the mines and have to be adjusted to meet the various freight rates.

CONCLUSION

To the careful reader it will be evident from the preceding that it is not only desirable to burn cleaned No. 4 buckwheat, but it is at the same time most economical if ample grate capacity is provided; and there will go hand in hand with it the preparation of No. 4 buckwheat, and the washing and concentrating of No. 5 buckwheat, which can be briquetted to a very valuable fuel, relieving some of the domestic sizes. But the results obtained show still more conclusively how important it is to use proper methods of firing and mixing, and the prime importance of keeping the market free from all fake products of unclean No. 4 or No. 5 buckwheat, uncleaned silt, or low-grade briquets.

G. H. SHARPE.[1] The Derby Gas Co., Derby, Conn., endeavor to provide, during the season of open navigation on the Housatonic River, an ample reserve stock of bituminous coal to carry the electrical department through the winter and early spring. The demands during the past winter exceeded the estimate, owing to the emergency power supplied to Waterbury, Conn., and to tide over it was decided to accept an offer of about 11,000 tons of No. 2 and No. 3 buckwheat, on which deliveries started in the latter part of March. The 11,000 tons were purchased under three contracts, the average analysis of which is about as follows:

Ash, per cent	20.52
Moisture, per cent	8.20
B.t.u. dry	11,587
B.t.u. as received	10,638

An average of 7000 lb. of buckwheat is loaded from the storage pile into a truck, and the truck is then filled up with bituminous, giving about 55 per cent of buckwheat per load. This is dumped at the power station, passing through a crusher and conveyor, and into the bunkers, resulting in a uniform mixture. From the overhead bunkers, the coal is delivered through a traveling weigh larry to multiple-retort underfeed stokers serving two 600-hp. Babcock and Wilcox boilers. The mixture is, as stated, about 55 per cent No. 2 and No. 3 buckwheat.

The fire carried is much thinner than with bituminous, and with a 2½- to 3-in. draft. The output of the boiler is reduced because of the lower heat value of the fuel.

The clinkers and ash are increased, resulting in a marked increase in cost of operation, as ashes are loaded by hand to trucks, pending completion of the new boiler room; but clinkers are more easily broken, so that less coke is lost in cleaning the dumping grate.

We are burning 2.20 to 2.21 lb. of coal per kw-hr. at the switchboard, with a maximum output of 6800 kw. and an average of between 5000 and 5500 kw., giving an overall plant efficiency of about 11.9 per cent.

The buckwheat costs $1 less than the bituminous, but the increased cost of ash disposal and lower heat value do not warrant additional purchases. The stokers handle the 55 per cent mixture readily, and I have no doubt that we could have made an equal showing, based on heat values, with 75 per cent or even 85 per cent of buckwheat.

R. SANFORD RILEY[1] (Oral). We in the stoker business who are primarily interested in the burning of bituminous coal are frequently asked as to the amount of anthracite coal that may be mixed with bituminous. To answer this question intelligently, we should know the characteristics of both the bituminous coal and of the anthracite coal that the questioner has in mind. The proportions mentioned by the previous speakers are very good; we find that up to 30 per cent of anthracite may be used.

Nearly all stoker manufacturers are advocating the necessity for large stokers. We think that the stoker is really the limiting factor. The maximum of stoker capacity should be put under the boiler. The reason for this is that the boiler investment cost per horsepower is very much greater than that of the stoker. I would like to emphasize that the mixture of anthracite and bituminous must be thorough; one cannot burn first a patch of anthracite and then a patch of bituminous.

E. B. WESSON[2] (Oral). We have a small Manning boiler plant which we fire one-half anthracite and one-half bituminous; and we mix the coal by taking the small industrial dump cars and filling them half full of anthracite, and then at the other end of the trestle filling them with bituminous. The cars are then dumped on the boiler-room floor.

J. M. SPITZGLASS[3] (Oral). It is surprising that in all this discussion so far the boiler has been treated as a consumer, and a bad consumer at that. It seems to be overlooked that the departments that use steam should be checked as to the use they make of it. The instrument that saves the most coal is the one that measures the steam produced by the boiler and the steam that is used by each department in the factory.

[1] Derby Gas Co., Derby, Conn.

[1] President, Sanford Riley Stoker Co., Ltd., Worcester, Mass. Mem. Am.Soc.M.E.

[2] Worcester, Mass.

[3] Vice-President, Republic Flow Meters Co., Chicago. Mem.Am.Soc. M.E.

A. G. Christie.[1] Last winter we purchased a considerable quantity of anthracite "yard sweepings" from domestic coal dealers for use in Taylor stokers under Babcock and Wilcox boilers in our University plant. This coal contained 16 to 20 per cent ash and averaged about 11,000 B.t.u. In general these screenings came from coal mined before the shortage occurred. It could be burned with perfect satisfaction in the stokers even at overloads when mixed as high as three parts of anthracite to two parts of Somerset semi-bituminous coal.

Later several cars of washed culm were purchased with from 25 to 40 per cent ash running 10,000 to 7000 B.t.u. per lb. The ash had a low fusing point and formed immense hard clinkers in the furnace when mixed and burned with semi-bituminous coal. It could only be burned with an equal portion of the Somerset coal when the demand for steam was small. In the furnace the fuel had a dull appearance and the finer particles tended to blow over on to the dump plates. It cascaded badly on dumping and during the removal of clinker. On the whole, we found the culm an uneconomical investment, although the yard sweepings proved economical when purchased at a reasonable price.

Carl Smerling.[1] Anthracite wastes such as culm and smaller sizes of buckwheat can be successfully consumed and burned, using a mixture of 1-3 anthracite and 2-3 bituminous coal, providing the bituminous is of a good coking quality and the fire can be carried 16 to 20 in. deep with natural draft of 0.7 in. at the stack breeching, and maintain a rating of from 125 to 150 per cent. On these conditions the stoker can be operated the same as when burning the straight bituminous coal fire. It is absolutely necessary to have sufficient bituminous coal to raise the temperature of the fire high enough to get all the value out of the anthracite coal.

5 What Instruments Are Useful and Desirable in the Boiler Room as Aids in Saving Coal?

What class of equipment has been of the most value to you, and how?

E. G. Bailey.[2] The answer to this question is: Meters that will actually *assist* the fireman to carry the load required of his boilers and at the same time obtain the maximum efficiency. The old idea of having meters and recorders to "show him up" if he did not do his work well, when he usually did not know how to do it better, is wrong.

The word "meter" is used here in its broad sense to include all instruments, pressure gages, thermometers, etc. down to coal scales and wheelbarrows when they are used to obtain knowledge of the operating and efficiency conditions.

Controllable Losses in Boiler Operation

In selecting meters, the principal object is to obtain knowledge of the boiler capacity and efficiency and also the individual losses, especially those which are controllable. To accurately know the losses is of much more importance than to merely know the efficiency, for efficiency can only be increased by reducing losses, and if one knows that the losses have been reduced, he is positive that the efficiency has been increased. The principal controllable losses in boiler operation are: (1) combustible in ashes and refuse, (2) excess air, (3) unburned gas, and (4) high temperature of flue gases. There are also other factors from an operating standpoint that are of importance, such as the steam pressure, superheat, rate of steam output from each boiler, evaporation per pound of coal, etc.

Meters are divided into four general types. Those which show condition; total; rate; relation.

Meters which show condition include pressure gages, thermometers, water level gages, etc. which in a boiler plant are used to measure steam and draft pressures; steam, flue gas and feed water temperatures; water level in the boiler and other similar factors. These meters may be either recording or indicating.

Meters which give total values or quantities, include coal and ash weighing or measuring devices, also integrator meters for water, steam, etc. These are usually indicating only.

Meters which show rate can be either recording or indicating, and include boiler feed, steam flow, air flow, stoker speed, etc. They may also be combined with integrating meters of the second type.

The three foregoing types are those with which we are most familiar and they have been developed and their general use extended in the same order in which they are named, while from an operating standpoint the value of these different types is practically in their reverse order. For instance, it is better for a fireman to know the rate of steam output from each boiler continuously than to wait until the end of his shift and learn the average rate from a water meter that integrates total only.

Results Should Be Known Promptly

The real valuable results from complete boiler tests, such as those made by Dr. D. S. Jacobus at Detroit some years ago, are not obtained until the many calculations involving averages and totals are made and the relations between the various factors is determined. In other words, the total evaporation or even the rate of evaporation gives no information whatever as to efficiency until we know how many B.t.u. were expended in producing this steam, or at least know how many B.t.u. were lost in making it. Time is an important factor in boiler operation and the fireman should know final results promptly and continuously. It is, therefore, desirable to have meters of the fourth type which indicate and record the relation between certain important factors as well as the condition, total and rate.

One of the important relations desired is that between rate of steam generation and rate at which fuel is burned. With liquid or gas fuels of uniform quality this is possible; but with coal, about the closest approach is the relation between a steam flow meter and tachometer on the stoker drive. The latter, however, is a crude means of determining the rate at which the B.t.u. are supplied to the furnace, and this is the real factor desired. It is doubtful if this will be satisfactorily attained, in the near future at least, due to the varying amount of coal fed per revolution of the stoker shaft and the varying quality of the coal, as well as variations in the amount of coal on the grate.

[1] Assoc. Professor of Mechanical Engineering, Johns Hopkins University, Baltimore, Md., Mem.Am.Soc.M.E.

[2] President, Bailey Meter Co., Boston, Mass., Mem.Am.Soc.M.E.

[1] Pres., Huber Hand Stoker Co., Inc., New York. Assoc-Mem.Am.Soc.M.E.

Relation of Steam Flow and Air Flow

There is another relation, however, that is analogous to the steam-fuel ratio that is readily obtained and of even greater value. It is the relation between the rate of steam flow from the boiler and the rate of air flow which supports combustion for the generation of this steam. Air is a fuel just as much as carbon or hydrogen, and the amount of air required to develop a given number of B.t.u. is practically independent of the character or quality of coal being used. In fact, there is only 6 per cent difference between the B.t.u. developed per pound of air used to burn carbon and natural gas. This is much closer than most people are able to maintain the excess air in coal fired furnaces. Natural gas is mentioned in this comparison because it contains a higher percentage of available hydrogen than any other commercial fuel.

There is ample evidence available to show that the relation between the steam flow and air flow is of value in assisting the fireman to maintain the most economical fuel bed and prevent undue losses in either excess air, or unburned gases. This relation is also of great assistance to the fireman in obtaining maximum capacity from his boilers, for he quickly learns that it is impossible to make steam without the proper supply of air and if the maximum air supply is equivalent to only 200 per cent boiler rating, then 200 per cent boiler rating is all he can get, unless he is willing to sacrifice efficiency and produce high percentages of unburned gases. Such a loss is plainly shown by this relation as a deficiency of air.

Another important relation in boiler operation is that existing between flue gas temperature and rate of steam output. We have only to refer to data plotted by Mr. Azbe[1] to see that there is a wide difference between results obtained from various boilers in different plants. While this relation depends upon the position of baffling and other features of design, it is perfectly definite for any one design, and a certain flue gas temperature should exist for each rate of steam output. Any deviation from this indicates dirty heating surface or leaky baffles, providing the proper relation exists between the rate of steam flow and air flow. Either a decrease or increase in excess air from the most economical amount will result in an increase in flue-gas temperature, except that a large percentage of excess air will reduce the temperature.

In boiler-plant operation there are several other factors which should be combined to continuously show the relations existing between them for the benefit of the fireman or operating engineer, whereby they can get at the true conditions and their causes with little mental effort and delay. A meter which shows a relation is in reality an automatic calculating machine which takes two or more factors and produces a tangible result, which would otherwise require the reading of two or more instruments and reference to charts or tables.

The question often arises in selecting any of the four types of meters as to whether they should be indicating or recording. Some of the best power-plant engineers were strongly in favor of indicating meters for boiler plant work a few years ago, but have now changed to be the strongest advocates for recorders. Practically the only argument that can be advanced in favor of indicating meters is lower initial cost and the lower cost of operation by elimination of charts.

Advantages of Recording Meters

Some of the many advantages of recording meters are: Permanent records to show conditions existing throughout the twenty-four hours; averages, totals and operating characteristics may be checked at any subsequent time; and of even more importance is the fact that it helps the fireman to see, not only the conditions at that instant, but also what the conditions have been immediately previous, and thereby ascertain whether they are changing, and if so, in which direction. This alone is of sufficient value to warrant the use of recording meters in practically every instance, providing they are located in the position where the man in charge of operation can readily see the chart record in detail. A water tender will do much better work when he has a recording feedwater meter within sight, than if the recorder were located in the engine room.

The firemen and operating men must have meters which serve as eyes whereby they can see through steam pipes and brick walls, so to speak, and actually know what is taking place. The meters that will give them true pictures in the most realistic and concrete form are the most useful in saving coal.

[1] Power Plant Efficiency, by Victor T. Azbe, Trans.A.S.M.E., vol. 38, 1916, p. 722.

WALTER N. POLAKOV. While the generation of power, and more specifically of steam, is the domain of the scientifically trained engineer, power-plant practice is conspicuous by the lack of accurate measurement of conditions and results.

Unless the results attained are known, no opinion as to perfection of operation can be formed; furthermore, the practice is necessarily wasteful unless means are available to observe the conditions under which the process is performed. All instrument equipment of the boiler house can, therefore, be grouped into two classes: those for recording the results; those showing the conditions.

A plant of which it is not known how many pounds of coal are used per 1000 lb. of steam, how the load is distributed among the units and throughout the day, etc., by necessity wastes fuel. The knowledge of these data does at least open the eyes of those responsible for its success, and further progress is thereby made possible.

The first group of instruments then comprises:

Quantity
- Recording coal scales
- Recording steam or water meters.

Quality
- Coal calorimeter and moisture scales
- Feedwater thermometer
- Steam pressure gage and thermometer.

The second group of instruments is intended to direct the processes by controlling conditions:

Conditions
- Individual flow indicators
- Individual draft gages
- Individual flue-gas thermometers
- Flue-gas analyzer.

Substitution of flow indicators by coal or oil meters is undesirable, as it leaves obscure the output for given input; draft gages may be substituted by pitot tubes. Other modifications are sometimes desirable, but the above equipment is necessary and sufficient in general cases.

Any investment in instruments is a pure waste of money, and will lead to demoralization unless means are provided for:

a Training men to properly use them
b Stimulating men in the proper use of them
c Complete, exact, and continuous recording.

Location and arrangement of instruments should be such as to:

a Permit simultaneous readings and their comparison

b Permit plain view of units from instrument board and vice versa

c Afford an opportunity to use one instrument for diverse units

d Eliminate unnecessary fatigue of observing scattered instruments

e Assure ease and simplicity for testing.

These requirements are combined in the type of instrument boards devised by the author, typical examples of installations being represented in Figs. 8 to 10.

The complete cost of such installations, including labor and material, averages $2000, and the returns secured on this investment are usually equal to or better than told in the following report from a plant using from 150 to 250 tons of coal per week:

"........ It is evident that in the four months preceding the installation of the boiler control board, the savings on fuel, due to various steps taken, averaged $435.00 per month, while, in the four months following the installation of the instruments, the savings computed on the same basis averaged $1145.00. In other words, the increased savings, due solely to the *intelligent use* of instruments on the boiler control board, was $710.00 per month, or $8620.00 on the annual basis, which means that the expenditure of $2080.46 for instruments of the said board is an investment which, in our case, yields over 400 per cent return."

The fallacy of economizing on instrument equipment or ignorant attempts to select "the most important" ones has only one rival in absurdity—the tendency of installing instruments without giving the employees the opportunity to use them to advantage. Obviously, the operating men have no time, no ability for research work, and little inducement, to carry out investigations, standardize methods, and set tasks. It should be the duty of the management to give them the necessary training and to assume responsibility for results.

A. R. Dodge.[1] Pressure gages and water-gage glasses are absolutely necessary to the operation of steam boilers. Next in importance is a steam-flow meter for the purpose of showing the amount of steam being delivered by each individual boiler.

Steam-flow meters in service have shown that in nearly every case a battery of boilers as a whole may be generating the required amount of steam, but the several boilers making up the battery fall far short of assuming equal subdivisions of the total.

Steam-flow meters installed on each boiler show at once a boiler which is "loafing," or one being forced too hard, conditions which cannot readily be detected in any other way. With this knowledge the necessary changes can be made in drafts, fires, etc., to equalize the steam output of the boilers. With the outputs equalized the danger of priming and burning out tubes and brickwork, due to excessive overload, is minimized.

Results obtained in many plants prove conclusively that the flow meters are a great aid to the firemen themselves in showing the results of their work. As soon as they learn that the flow meters show them the effect of changing the draft, fires, rate of feeding water, etc., they will be found using them as a working guide.

Holes and dead spots develop in fires, reducing the efficiency of combustion by allowing an excess of air. Should this occur, the steam output instantly drops and with a flow meter installed on each boiler, the fireman is warned that something is wrong.

Flow meters have been the means of indicating many other conditions which seriously affect the economy, such as leaky settings admitting quantities of air, burned-out baffles permitting a short-circuit of the gases, incorrect adjustment of feedwater regulators, or poor hand regulation, etc.

The use of draft gages, CO_2 recorders and a thermometer to show the superheat of the steam, in conjunction with a flow meter, enables the power-plant operator to keep a complete check on the performance of the boilers and furnaces, and to quickly eliminate faulty conditions as they occur and thereby to keep up the efficiency of the plant.

E. A. Uehling.[1] The continuous CO_2 record shows up the process of combustion for every minute of the day. The indicator at or near the boiler front keeps the fireman continuously informed of what he is doing. It shows him in a few minutes the effect of any change in the rate of fuel and air supply that may be necessary to keep the steam pressure level.

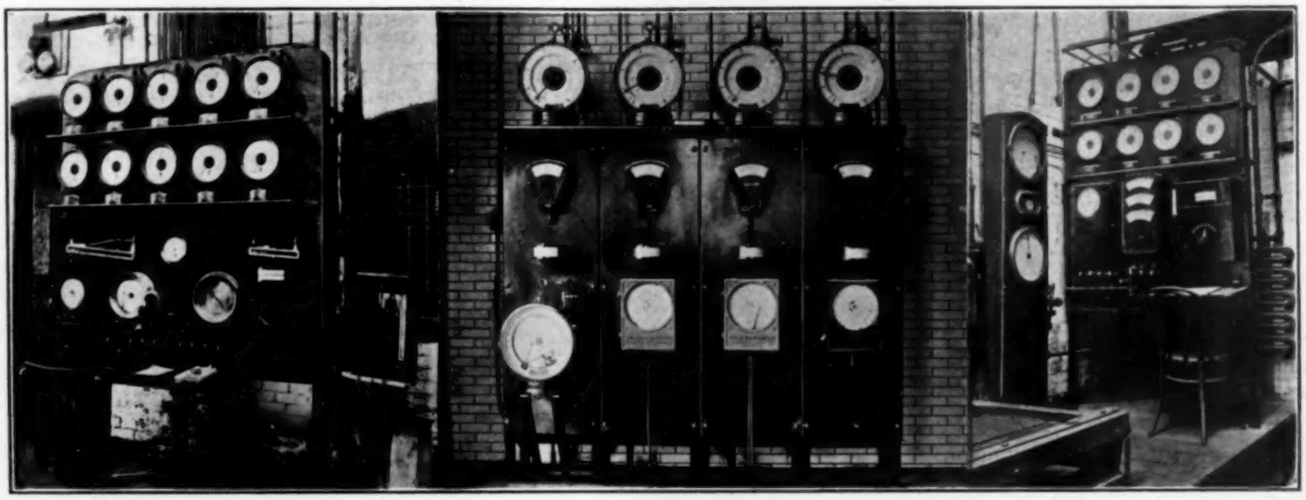

Fig. 8 Fig. 9 Fig. 10

Figs. 8, 9 and 10 Boiler and Combustion Control Instrument Boards

[1] Engineer, General Electric Co., Schenectady, N. Y., Mem.Am.Soc.M.E.

[1] Uehling Instrument Co., Passaic, N. J., Mem.Am.Soc.M.E.

What the CO_2 Shows

In hand-fired boilers the continuous record not only shows whether the proper per cent of CO_2 has been maintained, but also how often the fire was replenished, how long the fire doors were kept open, when the fires were cleaned, how long it took to clean them, and the improvement in the fire resulting from it. With an occasional check analysis by an Orsat the continuous CO_2 record becomes an unchallengeable exposition of combustion efficiency.

Combustion efficiency is the foundation of boiler efficiency, but it does not necessarily follow that maximum combustion efficiency will always result in maximum boiler efficiency. There is another factor of nearly, if not quite equal importance, viz., absorption efficiency. Absorption efficiency depends, first, on combustion efficiency; second, on the relation of heating surface to the rate of combustion; third, the routing of the gases through the boiler; fourth, the cleanliness of the heating surface inside and out, and fifth, air infiltration. The CO_2 meter should therefore be supplemented by at least two other instruments, viz., the pyrometer and the boiler draft gage, preferably the draft analyzer, which shows both the furnace draft (resistance through the fire) and the boiler draft (resistance through the boiler). The pyrometer does not by itself give reliable information, but if its readings are coordinated with those of the CO_2 meter and the boiler draft gage, a complete and reliable control over absorption efficiency is had. The boiler draft gage gives immediate notice of broken down baffling, and in combination with the per cent of CO_2 its readings furnish an approximate index to the rate of combustion.

It would be useful to have, in addition to the above, a steam-flow meter on each boiler, since they would furnish a quantitative check on every boiler and fireman in addition to the chemical and physical qualitative control which I have mentioned as necessary and adequate to attain and maintain maximum boiler efficiency dependent only on plant—fuel—and operating conditions. The installation of a steam-flow meter is therefore to be highly recommended.

It is evident from all this that no boiler plant large or small should be without an Orsat, that the CO_2 recorder should take precedence over other more or less expensive equipment. Although the CO_2 recorder gives all the information necessary to control combustion efficiency, a pyrometer and draft analyzer are necessary in addition to control boiler efficiency. In general any instrument that will give useful information is a desirable addition to the equipment.

Wholesale control by means of water meter and coal weigher is most valuable to the manager in many ways in addition to those already mentioned, and any plant the size of which warrants the expense should install them.

There are many other instruments and apparatus of greater or less importance and utility which the prescribed space and time does not permit me to discuss. I may say, however, that all have their talking points and in a measure fulfil their advocated functions; but since they ignore the fundamental principle of combustion, they cannot give information adequate for complete control over boiler operations.

R. P. Brown.[1] The temperature in the furnace and the distribution of this heat throughout the boiler must be learned and studied carefully. The firebox is at such a high temperature that except for test purposes it is not practical to install an instrument at this point. An electric pyrometer can be used to secure by test the temperature in the firebox using a platinum-rhodium thermocouple, but most frequently the pyrometer is installed so that the temperature of the last pass, or in the uptake, is secured.

The temperatures in the firebox are approximately 2500 or 2750 deg. fahr., which is too high for a permanent installation. In the last pass the temperatures average about 1000 deg. fahr. and in the uptake about 400 or 600 deg. fahr. At these lower temperatures base-metal couples may be installed without danger of rapid deterioration. The temperatures in the last pass and uptake have been found to be comparative to those in the firebox; so that a working temperature is secured to which the fireman can work.

If actual practice shows that 500 deg. in the uptake or a corresponding temperature of 1000 deg. in the last pass of a boiler results in securing the maximum efficiency, then the fireman should use this temperature as a guide. The slightest irregularity in firing or change in furnace conditions are readily noted before the corresponding change in pressure may occur. If the flues are dirty and sooty the heat cannot be absorbed and instead pass up the stack, and a correspondingly high stack temperature is secured. If the baffle walls become cracked or broken down the heat will not circulate properly, and again high stack temperatures.

In addition to the usefulness of temperature and pressure recording instruments, there has recently been evidenced an increased interest in electric tachometers for registering the speed of the shafts on automatic stokers. The rate of firing naturally bears a close relationship to the amount of coal used. A small generator is attached to the end of the stoker shaft by means of gear or sprocket and chain drive. It is so geared that about 15 to 25 volts are generated at a speed of approximately 1000 r.p.m. of the generator. This voltage is carried to the instrument by means of wiring. As this can readily be strung for long distances, the instruments may be located wherever most desirable.

[1] President, Brown Instrument Co., Philadelphia, Pa.

C. W. Hubbard.[1] The evaporation figure might strictly be classed as a "half truth." When this figure has been arrived at, without supplementary data, one man's guess is as good as another as to whether the results obtained are all they should be.

The most useful instruments in the boiler room are draft gages, an Orsat apparatus, a CO_2 recorder, and recording thermometers for the feedwater line and the flue-gas temperatures. In addition to this, systematic tests of coal and ashpit refuse are necessary, for it is obviously unfair to expect the plant to operate at a given standard when it may be, and probably is the case, under present conditions, that the fireman is being furnished with greatly inferior coal.

It has been a common experience of the writer to be able by thus studying the preventable losses in the plant, to make a saving of from 10 to 20 per cent within a period of a month, and when I say 10 to 20 per cent I do not mean in power saving but I mean actual tons of coal wheeled into the boiler room.

R. H. Kuss. The question requires two sets of answers, because for the fuel engineer the entire range of instrument equipment may be made useful, whereas for the operating engineer of the usual grade, a very limited number of instruments are of any special service.

Instruments an engineer can use to advantage are those

[1] Fuel Engineering Co., New York City.

which he can understand; those that prove useful are such as require little attention to keep operating and which reveal maladjustment by simple test. The most useful and simplest instrument for the boiler room is a draft gage, preferably of the differential type. A draft gage or draft-gage system, if continuously used, will show to the careful observer—

a Developments of leaks, uncleanliness, baffle failures, etc.
b Poor fuel-bed construction.

Less difficult to interpret but much less useful than draft gages are thermometers or pyrometers. The difficulties in using pyrometers are those only of placing the bulbs or couples in the proper places so that the indication may be a true one of the condition investigated.

Gas-analysis instruments, while highly necessary for more refined investigations, are so seldom used by operators of plants of the middle or smaller size that as a general proposition it is useless to place them in the operating engineer's hands. The writer strongly endorses the use of coal-weighing and water-measuring systems.

The great difficulty with the subject is that, however useful the instrument may be, the supervising or engineering forces of boiler plants neglect to employ them to an extent their value justifies. The conclusion is inevitable that they should be few in number but of the recording type rather than indicating alone. The reason is that a record affords the opportunity of not only checking up the operating performance while going on, but gives the managerial forces the opportunity of checking up the operating engineering forces.

Walter E. Bryan.[1] When a number of boilers are connected to the same stack, it is particularly advisable to have each boiler equipped with a draft gage so that the gas passages can be regulated in the individual boilers with the result that more work will not be required of some boilers than others. Steam-flow meters are also advisable in stations where turbines are used and the flow is not pulsating. Readings of stack temperatures, CO_2, etc., should be taken at intervals, the latter with a view to calling attention to leaks in settings, etc. A recording CO_2 instrument arranged with connections to the various boilers is a valuable adjunct to the fireman.

B. J. Denman.[2] I believe the most useful instrument in the boiler room to be the one which indicates the percentage of CO_2 in the flue gas. In larger stations, with boilers of 1000 hp. or more, an automatic CO_2 recorder is justified. In smaller units, each boiler should be equipped with a gas collector and the Orsat apparatus, to determine the percentage of CO_2. Samples should be analyzed at least once during each watch. We regard the steam-flow meter as essential and as important an instrument as an ammeter or a wattmeter on a generator, and even more important from an efficiency standpoint. It is important that efficiencies of all the boilers be known over a wide range of loads and that they be operated at the most efficient point. It is not of much value to determine the efficiency curve unless its indications are followed, and this can only be done by the use of a steam-flow meter. These will show not only the number of boilers to have in service, but the division of the load between the units. With the underfeed type of stoker, we believe it is necessary to have instruments indicating the draft over the fire and at the damper, as with this type of stoker practically balanced draft can be carried, and this is the furnace condition which is most conducive to economy, through a reduction in the infiltration of air. Flue-gas-temperature recorders are desirable, but not essential, as the release temperature will take care of itself, if the boilers are kept clean and operated at the most efficient point, except for short periods during the peak.

A. G. Christie. Our University plant contains Babcock & Wilcox boilers and Taylor stokers with steam-pressure regulation on the blast and a balanced-draft system on the flue-gas damper. We have found that the instruments which receive the attention of our firemen and enable them to obtain the best results are draft gages on the blast and over the fire, a pyrometer in the breeching and a CO_2 recorder. The latter takes much skilled attention but produces results. We have been experimenting with a new blast regulator which promises to give better results than the usual type. Steam meters combined with coal-weighing devices are most desirable additions to the plant. Then records of coal and water consumed can be posted daily for the information of the fireroom shifts.

C. E. Van Bergen. We regard the draft gage as necessary on every boiler. It is not possible for a fireman to know what amount of air is passing through or over his fires, by simply looking at them. A steam-flow meter is valuable in showing the output of each boiler and all plants, except small ones, should have a continuous record of CO_2.

It is our belief that any plant expending $5000 or more per year for fuel cannot afford to be without these instruments. The draft gage has shown us that we formerly did not have proper adjustment of stack damper and ashpit doors. The steam-flow meter has given us valuable information on our monthly and yearly output and the flue-gas analyzer shows us the result of careless firing.

6 What Is Essential to the Economical Operation of Hand-Fired Boiler Furnaces When Using Soft Coal?

Helpful hints as to firing methods, front or side; frequency of firing; management of dampers; cleaning, etc.

Henry Kreisinger. The right proportion of the air supply to the weight of the coal burned is the most essential requirement in the economical operation of hand-fired boiler furnaces. The removal of ash from the furnace is done with the object of keeping unobstructed the supply of air through the fire. The fireman shakes the grate or cleans his fires because the ash and clinker restrict the supply of air through the fuel bed.

In the boiler furnace about 14 lb. of air are necessary to burn 1 lb. of the average soft coal. This air must be introduced into the furnace in such a way that it is brought in direct contact with the coal and the gases rising from the fuel bed.

[1] Supt. of Power Stations, United Railways Co. of St. Louis. Assoc-Mem.Am.Soc.M.E.

[2] Pres., Tri-City Railway & Light Companies, Davenport, Iowa. Mem.Am.Soc.M.E.

The Bureau of Mines has shown that in the hand-fired furnace, if the fuel bed is level and 5 to 6 in. thick, only about 7 lb. of air can be supplied through the fuel bed to each pound of coal burned. If an attempt is made to force more air through the fuel bed, only the rate of combustion or gasification is increased, and the ratio of the air to the coal burned or gasified remains constant.

The gases rising from the fuel bed contain a large amount of combustible, about 8 to 10 per cent of CO_2 and practically no free oxygen. To burn this combustible an additional 7 lb. of air must be supplied over the fuel bed, and should be supplied in a large number of small streams and as close to the fuel bed as possible, in order that it may be mixed readily with the combustible. This air is introduced through the dampers in the firing doors, through the cracks around the firing door, along the side walls and the bridgewall, in some cases through special openings in the bridgewall, and very commonly through holes in the fuel bed.

Difficulty of Maintaining Proper Air Supply

In hand-fired furnaces it is difficult to maintain the 14-to-1 proportion of air supplied to coal burned, because usually the air is supplied continuously and at a uniform rate, whereas the coal is charged intermittently at intervals of 2 to 20 min. duration. The ash is also removed intermittently at intervals of 3 to 24 hours, depending on its quantity and character. It is this intermittent feeding of coal that makes the proper proportioning of air to coal difficult. From the fireman's standpoint, soft coal consists mainly of two kinds of combustible, namely, volatile matter and fixed carbon. The volatile matter is that part of the coal which is driven off as gases and tars when the coal is heated, whether air is supplied to burn them or not. The fixed carbon is that part which stays on the grate after the volatile matter has been driven off and until burned or gasified by the air flowing through the fuel bed. When the fuel is 5 to 6 in. thick the fixed carbon is not completely burned, but a considerable portion of it leaves the bed in the form of CO. In the first 3 or 4 in. above the grate the carbon burns to CO_2, of which a large part is reduced to CO in the upper layer of the fuel bed.

Thus, immediately after firing while the distillation is taking place, the fuel bed acts both as a gas retort and a gas producer; after the volatile matter has been driven off the fuel bed acts only as a gas producer. Therefore, immediately after firing sufficient air is needed over the fuel bed to burn the gas from the gas retort and also from the gas producer. After the distillation has been completed only enough air is needed to burn the producer gas. With a constant air supply over the fuel bed it is impossible to have sufficient air to burn the gases completely while the process of distillation is going on without having too much air after the distillation has been completed.

Adjustment of Air Supplied to Quantity Needed

In order to have the right amount of air in the furnace at all times, two methods may be used: (*a*) The air supply over the fuel bed may be varied during each firing cycle; or (*b*) the distillation or the gas-retort process may be extended over the entire firing cycle.

There are devices to vary the air supply over the fuel bed automatically which, with proper attention, give good results. However, with the ordinary hand-fired furnace the fireman can approximate their action by cracking the firing door for a short period after firing.

The method under (*b*) is probably more practicable. Each new charge of coal can be heated slowly so that the distillation extends over the entire firing cycle.

With the coking method of firing the coal is placed in large charges on the front part of the grate, where it is heated slowly. When the distillation is nearly completed, the coal is spread over the grate and a new charge placed near the firing door. This method is feasible for heating boilers, but is objectionable for power-plant boilers.

For power-plant boilers the most practical and economical method is to shorten the period of firing so that distillation extends nearly from one firing to another. In order to eliminate the danger of piling the fresh coal on top of coal from which the volatile matter has not been completely distilled, half of the grate area should be covered at a time—the alternate method of firing—and the firing be so timed that half of the grate area is distilling volatile matter all the time. This may require that the firing be done at about 2-min. intervals, or even more frequently. The charges, of course, should be small so that there will be no tendency of the coal to form heaps; they should be spread over the thin spots of the fuel bed, avoiding the thick spots.

Frequent firing reduces the chance of the fuel bed's burning out large holes, which would let into the furnace too large an excess of air. With the caking or coking coals the holes in the fuel bed may not always be due to coal burning out faster in the thin spots, but to shrinkage of the fuel bed, which causes cracks to form. Once a crack is formed, the air rushes through and burns the coal on each side of the crack, rapidly making it larger. This explains why with eastern coking coals it is much more difficult to keep the fuel bed free from holes than with the free-burning coals such as come from the Illinois coal field. Frequent firing and the alternate method, to some extent, reduce the harm that may come from holes in the fuel bed.

Effect of Frequent Firings

Fig. 11 shows the effect of frequent firings of Illinois soft coal on the air supply and the composition of the furnace gases. The points connected with the solid, heavy line are the readings of CO_2 taken with an interferometer, and those with the dotted line the indications of CO_2, shown at the same time by a Uehling CO_2 recorder. The interferometer gives the CO_2 contents in the gases at the instant when the observation is taken, but the Uehling recorder has a lag of about 7 min. and a tendency to average the CO_2 readings over the entire firing cycle. The time of firing is shown by the black rectangles at the bottom of the chart. The interferometer shows plainly very high CO_2 immediately after each firing, followed by a rapid drop. This variation in CO_2 indicates very little or no excess of air after firing and considerable excess immediately before firing. The drop in CO_2 is much more pronounced with the 5-min. firing periods than with the 2½-min. periods, indicating that in the latter case the air supply is kept more nearly proportional to the weight of coal burned.

One-half of the air supply was introduced through the grate and the other half over the fuel bed through fourteen 1⅛-in. nozzles. Both air supplies were measured. The nozzles were placed in the side walls and injected the air in horizontal streams close to the surface of the fuel bed. The grate area was 30 sq. ft. and the rate of firing was 22 lb. of coal per sq. ft. of grate per hour.

FIRING METHODS WHICH GIVE GOOD RESULTS

Good results can be obtained with a fuel bed about 5 to 6 in. thick. Heavy fuel beds offer high resistance to flow of air, making it necessary to carry high draft in the furnace and setting. High draft increases air leakage into the boiler setting and causes losses from the large excess of air. Furthermore, thick fuel beds cause excessive clinkering and the high losses connected with the frequent cleaning of fires. Higher rates of combustion can be obtained with thin fires than with thick ones.

The draft damper should be so adjusted that the air supply through the fuel bed is always just sufficient to burn the coal at the same rate it is fired. The accumulation of ash and clinker on the grate will gradually increase the resistance through the fire, and the draft should be accordingly increased. Sudden large changes in the damper should be avoided.

Perhaps the best and most generally used method is where the live coals and coke are pushed or thrown to one side of the furnace, leaving the refuse, which is raked out. The clean grates are then covered with clean fire from the other side of the furnace, which is then similarly cleaned.

I believe that more fuel is wasted by operating with leaky boiler settings than in any other way. All boiler settings, therefore, should be kept up to the highest possible degree of tightness. This can be done by stopping up all of the larger cracks with some good filler and then applying a generous coat of a first-class plastic cement, which will effectually seal all small cracks and pores in the brick. The settings should be gone over at regular intervals by a competent man and repairs made where needed.

The most important thing, however, in the economical operation of hand-fired boiler furnaces, whether using soft coal or some other fuel, is to have a well-trained, efficient corps of men who are heartily in accord with their chief and his policies. This is extremely difficult to bring about, but it can be accomplished by systematic hard work, sprinkled with a little diplomacy. The governing head or superintendent, first of all, should be master of himself. This will command the respect and loyalty of those under his direct control. He should study human nature, for this will enable him to select the class of men who will stand by him. He, in turn, should stand by them, take an interest in their affairs, outside of business, and give ear and patience to any condition arising wherein their interests are involved.

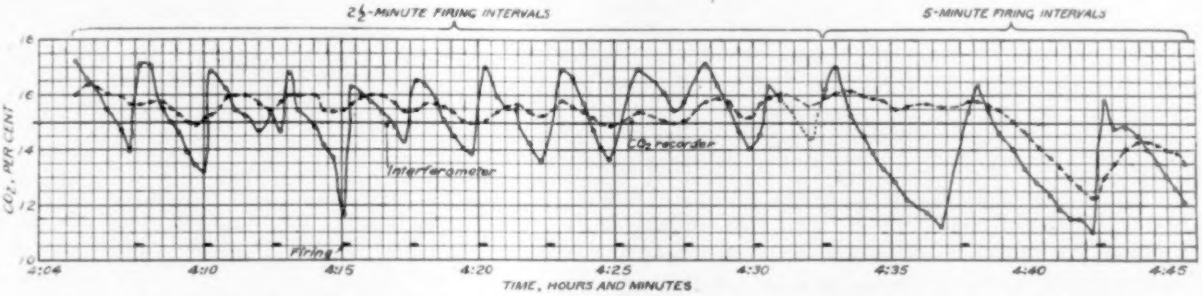

FIG. 11 CHART SHOWING EFFECT OF FREQUENT FIRINGS ON AIR SUPPLY AND COMPOSITION OF FURNACE GASES

Fires should be thoroughly cleaned at regular intervals and at times when the load on the boiler is reduced, such as the noon periods. The side cleaning method by which one side of the grate is cleaned at a time is recommended. After cleaning the fire should be built up gradually. A day's shift should start with a clean fire. Perhaps nowhere is a good start of such great advantage as in running a furnace.

INDICATING INSTRUMENTS OF PRIME IMPORTANCE

E. E. HUNTER.[1] One of the prime essentials to economical operation of hand-fired boiler furnaces when using soft coal is to have boilers and furnaces equipped with the necessary instruments as guides or indicators, of which a reliable CO_2 machine and draft gages are the most important.

The method of firing to be used depends largely upon the quality of coal and upon the nature of the load to be carried. For a steady load a slow-burning coal which cokes nicely may be used to advantage, because there will be no sudden demands for steam and a thick fire can be carried, which should not be disturbed except when absolutely necessary.

On the other hand, with an erratic, unsteady load a quick, flashy coal high in volatile matter will no doubt give satisfaction, and the fuel bed in this case should not be very thick and should be fired lightly and often according to the steam demand.

The alternate method of firing is recommended by some, but I believe the best one is to fire every door, with the fire doors kept open the minimum length of time. The firemen should be given long and careful instruction in the manipulation of the dampers, guided by the draft gages, and should regulate their draft according to the demand for steam.

Fires should be cleaned at a time when there is the least demand for steam, and as quickly and thoroughly as possible.

[1] Chief Engineer, Oklahoma Gas & Electric Co., Oklahoma City, Okla.

GEORGE H. DIMAN.[1] This is a subject in which I have been very much interested for over fifty years, but I have been discouraged many times by the indifference shown by the managers and owners of power plants. I know of no department in any manufacturing concern where there is as much waste as in the boiler rooms of our manufacturing concerns in New England.

To get good results, the managers and engineers should coöperate. As an illustration of what I mean, let me say that I was employed in 1883 to take charge of eight mills, four woolen and four cotton, under two different agents, with the understanding that I should make a saving without spending any money for new appliances. The first six months before I took charge it cost $36,327.30 to operate the steam plant; the production of cloth was 812,363 lb. Every six months the power-plant cost was decreased, and for the six months ending November 30, 1884, the cost for operating the steam plant was $20,950 and the cloth production was 1,257,353 lb., this increase in output being due to the fact that more machines were running than when I took charge. The reduction of costs was accomplished entirely by systematizing the boiler plants

[1] Consulting Engineer, Wood Worsted Mill, Lawrence, Mass.

and by the aid of the managers of the mills. The same antiquated equipment was used throughout this period.

If I were to hire an engineer to take charge of a steam plant, I should have the man examined to see whether he thoroughly understood the economical burning of coal, and should be very careful to see whether he had tact in regard to handling men. It costs nothing to say "Good morning" to the humblest employee, and it should be remembered that there is just as warm a heart under the ragged shirt as under the best broadcloth.

In all the fifty years that I have employed labor, I have never gone outside the mill gate to hire any men—always promoting the men in the yard. This gives the men an incentive to work. As an illustration, the chief engineer at the Ayer Mills was formerly head fireman at the Wood Mills.

Before touching on the method of firing to secure economy, I will quote a letter from Admiral Cone of the Bureau of Steam Engineering at the time when he was chief engineer in the United States Navy:

DEAR MR. DIMAN:

We have had yours pertaining to economical burning of coal for some time, for which we thank you. We have already published it in our Bulletin to be used in the Navy. We thank you for helping us along.

Yours respectfully,
H. I. CONE.

So it will be seen that what I am going to say about methods of firing was approved and adopted as indicated by the above letter.

Firing Methods That Have Proved Successful

First, I should have the grates not over 7 ft. in length—6½ ft. would be better—as it is impossible, if the grates are longer than this, to keep the back end of the fire covered. I should set the boilers no less than 4 ft. above the grates—5 ft. would be better. This insures a good combustion chamber. It will be noticed that the boiler makers use practically the same size of ashpit door with a 250-hp. boiler that they do with a 600-hp. boiler. This gives a great supply of air near the doors, but none in the middle of the grates. I should dispense with the ashpit doors, cutting away the boiler front the full width of the grates. This gives an even distribution of air underneath the grates.

I should start with the fire 14 in. thick and try to keep it the same thickness through the day's run. I find time firing the best, and in our mills in Lawrence we adopted the system of firing every ten minutes, putting on the number of shovelfuls required to keep the fire the same thickness and maintain the power. I find that from 5 to 6 shovelfuls of coal is plenty. It takes about four to five minutes for a man to coal one side of two boilers and level the other side. This gives him five minutes to rest. I would recommend the boilers to be run about 50 per cent above rating. This would insure a very hot fire. Firing one side at a time prevents smoke. We have 44 boilers at our Wood Mills. They fire one-half of these boilers at a time—that is, one side, and level the other side of the same boilers. When they have finished, the men on the opposite side start and do the same. Every man has a chair to sit in, and in a 10-hour run the men are on their feet about half of the time.

I would use a good shaking grate which keeps the fire free from ashes, and would avoid slicing as much as possible, as this makes clinkers.

The dampers should be set so that all of the boilers will have the same draft. If the steam damper is used, I would have this adjusted so that it cannot close tight. When the damper closes tight, the furnace commences to make gas (CO), or utilizes 4450 B.t.u. instead of 14,400 B.t.u. We used to think that we were saving coal with the dampers shut, but we knew little about carbon monoxide then.

I should avoid cleaning the fires in working hours, preferring to clean them when the mill is stopped. If the fires must be cleaned while the mill is running, I would have one side of the fire burned down; clean the refuse and ashes out clear to the bridge wall; throw the coal from the other side that is unburned; coal that over, and when that is kindled up clean out the other side and coal that up. This insures a clean fire all over the furnace.

We hear a great deal about the great loss from opening the doors when hand-firing, but I have not found this to exist. If one will watch the operation of the steam-flow meter, he will find that the horsepower of the boiler does not drop when the fire door is opened. I have had both doors on a boiler open for one minute, and have seen no perceptible difference. The greatest loss comes from the uneven feeding of a boiler with water. I have seen the registration of a meter on a boiler drop from 500 hp. to 250 hp. in one minute, due to the fireman's opening the valve carelessly.

It is very necessary, in order to get economical results either with hand firing or stokers, to keep the boilers and the tubes perfectly clean, and to stop all air leaks around the boilers. On our boilers at the Wood Mills we blow the tubes every eight hours—three times in 24 hours, and open up and wash out the boilers every two months—that is, a certain number every week. We have very good water. If the water were bad, we would have them done oftener. I was once found fault with because the men used so many manhole gaskets, but I told the manager that manhole gaskets were cheaper than boiler makers. I never heard anything more about manhole gaskets.

7 To What Kinds of Plants and Coals Are the Different Types of Mechanical Stokers Respectively Adapted, and What Is the Limiting Factor to Their Use in the Small Plant?

JOSEPH HARRINGTON.[1] The usual and generally accepted classification of coals from the viewpoint of the mechanical-stoker manufacturer and operative is based on the tendency of coal to fuse together upon the application of heat and form a solid mass, or piece of coke, which is impervious to air at ordinary draft pressures. Those coals which act in this manner are called coking coals, and to prevent this cementing action the fuel bed must be kept in agitation during the period when the tarry element is being formed. This feature has limited the field of the chain-grate stoker and those forms of this stoker which leave the fuel bed entirely quiet have been effectually excluded from the coking-coal territory. For this reason, those stokers which agitate the fuel bed and

[1] Member of Conservation Committee, United States Fuel Administration for Illinois. Consulting Engineer, Chicago, Ill. Mem. Am.Soc.M.E.

those which supply air under artificial pressure have been found most suitable to these fuels.

The success of the inclined and gravity underfeed stokers has been due in large measure to their adaptability to this particular characteristic of eastern coals.

Reclassification of Coals on Ash-Content Basis

Attempts by the manufacturers of this equipment to enter the high-ash and high-volatile regions of the Middle West have developed another significant feature which is becoming all important, and to a large extent is going to supersede the former system of classification. One of the characteristics of Middle West coals is the relatively high ash content. The use of stokers which disturb and agitate the fuel bed has shown in emphatic manner the importance and value of reclassification based on the ash element. This classification may parallel to a large extent that based on the coking qualities of the coal, heretofore regarded as the broadest division. Neither the coking nor the ash features afford a clean-cut and definite line of separation because the coals of the country are of all grades and intermediate qualities, and shade one into another by almost imperceptible gradations. Broadly speaking, there is a very definite difference between the coals found east and west of Pittsburgh.

I would, therefore, reclassify mechanical stokers along the following lines, and consider this classification as vital in their successful application to the immense territory lying west of the Alleghany Mountains:

While there are many variations in the design of stokers, they all fall into one of two classes; first, those having the grate surface immovable, or non-progressive, the fuel traveling bodily over the grate surface impelled either by purely mechanical means, or mechanical means aided by gravity; and second, those having the grate surface movable and traveling at the same rate as the fuel, the latter resting undisturbed thereon. Consideration will show that this is a basic stoker difference and hereafter must be given its full importance or value in assigning a type of stoker to a given region.

As previously stated, coking coals must be agitated during the early combustion stages and it is this which limits the application of the chain grate to the eastern fuels, and not the low ash content which is also characteristic.

On the other hand, those stokers which naturally and inevitably agitate the fuel get into trouble from this very cause when handling the high-ash western coals.

Fuel-Bed Disturbance Important Feature in Stokers

Extensive and careful observations impress me with the fact that the fuel-bed disturbance is and must continue to be the most important single element in mechanical stoking. When these fuels are burned at a rate which produces fusing temperatures in the furnace, the ash will either liquefy or soften so as to be sticky and the slightest disturbance will cause it to ball up and form clinkers of immense size. The more it is agitated, the worse this trouble becomes. At rates of combustion which are possible with the underfeed type of stoker a limit is actually reached, and the fire gets into such condition that operations must be stopped to allow the cleaning of the furnace. Even if it is possible to dump the refuse as formed, ashpit conditions become intolerable and it is almost impossible to remove the ash under these conditions. I am becoming convinced, therefore, that the efficiency of the otherwise highly efficient type of stoker, which we know as the underfeed or inclined type, is largely offset by the unavoidable ashpit losses and the excessive amount of labor which must be expended in removing the hot ash and clinkers, which come from these stokers, and in controlling the side-wall accretions. Observations accompanied by analysis both under test and under ordinary operating conditions show that from 20 to 50 per cent of combustible will be found in the ash, and that this represents anywhere from 3 to 6 per cent of the total coal fired. It is possible to burn such high-ash coals with not to exceed 20 per cent of combustible in the refuse and when conditions are right 10 per cent can readily be obtained.

I should, therefore, like to call attention to this fact and suggest that the ultimately successful stoker for the region lying west of Pittsburgh will be one which does not agitate the fuel, and which discharges the refuse as formed and at the same time does not admit to the furnace more than the usual requirements in the way of air. It is possible to burn these fuels on this type of stoker with the proper amount of air per pound of coal, and when the draft is intensified by mechanical means, rates of combustion in conformity with modern requirements can be developed.

Great stress is invariably laid upon gas analysis, and without question it is a most important index of furnace efficiency. Recent developments, however, have shown another and serious source of loss, which, while it has been recognized, has not been given its proper weight. The ashpit is the source of loss to which I refer and before conservation can properly be carried out, this loss must be largely eliminated.

The answer to the question as to the minimum size of installation which warrants the application of mechanical stokers must be relative and not absolute, since there are at least two variables which enter into this combination.

Any application of mechanical stokers which pays for itself in three years is warranted. Paying for itself may be made up by reduction in the cost of the coal used, in a reduction of the labor required in operation, or both. A stoker will use up its value in fuel three times a year so that it is only necessary to secure a relatively small reduction in the price of coal to show a large profit on the cost of the installation. Labor enters into this proposition almost as importantly as does coal, since the supply of labor is becoming scarce and higher priced every day.

The great thing, however, for the country to consider at present is the opportunity which undoubtedly exists to burn lower grades of coal in a fairly economical manner, by the use of proper stokers, than can be burned in the hand-fired furnace. Coal which ordinarily would be classed as refuse, containing 40 per cent in ash, 7 per cent in sulphur and 15 per cent of moisture as fired, is being successfully burned in more than one plant.

The Field for the Mechanical Stoker

It would be practically impossible to develop rating by hand firing this fuel. If, therefore, the small hand-fired plant ordinarily accustomed to burning a good grade of lump or sized coal can secure a supply of screenings, even though they be of a low order, and provided they can be purchased at a reduced price, it can well afford to install a mechanical stoker. It is recognized that the small stoker costs out of proportion to its active grate area but at the same time the percentage in saving may be greater than in the case of the larger installation because the fact remains that the small installation is usually the worse offender from an economic standpoint.

Authentic cases of 25 to 30 per cent reduction in the cost of coal abound when this change has been made. From a theoretical standpoint, at least, there is no minimum limit in the practical size of steam boilers suitable for the application of mechanical stokers. Merely because stoking has been developed with the larger units is no reason why it should not be developed for the smaller unit, and in consideration of the large percentage of the total fuel supply that is consumed in the very small plant, it is imperative that engineers give this phase of the question their earnest consideration. If the stoker does not exist which is suitable to a 50 or 75-hp. boiler, it must be developed, and my prediction is that it will soon appear on the market in perfected form.

The answer, therefore, to this part of the question is literally that there is no minimum limit to the size of boiler adapted to the use of a mechanical stoker; but interpreting the question as it will ordinarily be, my opinion is that anything over 150 hp. becomes a possible field for the application of the stoker.

J. Van Brunt.[1] The selection of mechanical stokers with regard to coal and size and character of plants presents a problem that can only be answered in each individual case, and the proper solution can be reached only when all of the factors entering into the problem are known.

It is hardly advisable to arbitrarily classify plants, stokers and coal and attempt to predetermine on the basis of such classification the proper mechanical stoker. For the purpose of discussion, however, stokers and coals may be classified, and in a general way plants may be divided in four classes: Underfeed stokers; traveling or chain grates; overfeed stokers, and miscellaneous, such as powdered-fuel burners, shovel or scatter stokers, and semi-mechanical grates.

Classification of Stoker Plants

Underfeed stokers are again subdivided into multiple retort as the Riley, Westinghouse and Taylor; single retort with dead grates (Jones), and single retort with inclined moving grates as the Type E. Chain or traveling grates are of two types, differing principally in the fuel-bearing surface. In the chain grate the grate surface is composed of a large number of links held together by through bolts making a broad band of endless chain on which the fuel is carried. The traveling grate, on the other hand, consists of a number of grate bars or sections of grate bars held on cross-members, which in turn are fastened to the driving chains at either side of the stoker. The chains are thus below the fire line, and not subject to the heat as in the chain grate. There is a further division of such grates in forced-draft and natural-draft grates. Overfeed stokers may be front feed as the Roney or side feed as the Murphy and Detroit. The semi-mechanical grates and miscellaneous stokers need hardly be described further.

Coals present such a wide range of qualities aside from their approximate analyses and heating value that it is difficult to present a satisfactory classification.

Coal Classification

We have anthracite, semi-anthracite, semi-bituminous, bituminous, sub-bituminous and lignite. Recently coke breeze has become a recognized boiler fuel. As to size, anthracite steam coals are known as No. 2 buckwheat or rice, No. 3 buckwheat or barley, No. 4 buckwheat or No. 2 barley, and culm and silt, the last-named being a waste product now used as steam fuel only by some of the anthracite coal producers. Anthracites are also free-burning, and non-free-burning, clinkering, and non-clinkering. Soft coal is shipped as run of mine, slack, and nut and slack (also known as stoker coal).

Semi-bituminous and bituminous coals may be coking or non-coking or free-burning, caking or non-caking, high-ash, low-ash, and the ash may fuse at low or high temperatures. Sub-bituminous coal is generally free burning, but may be caking or non-caking, and will have great variation in ash content.

Lignite has the peculiar property of carrying as high as 30 per cent moisture held in the cellular structure of the coal, while in appearance the coal is dry. Its specific gravity is low, and volatile content equal to and sometimes greater than the fixed carbon. Air drying will remove nearly one-half of this moisture, but the lignite slacks badly in the process, breaking up into fine particles, which are extremely difficult to burn.

Types of Boiler Plants

Boiler plants for the purpose of this discussion may be divided into four general classes as follows: First, low-pressure heating plants of one or two small boilers, including such small high-pressure plants of similar size as are found in some office buildings and factories where the load is small and the boiler set so low that a satisfactory stoker installation is impossible except at prohibitive expense; second, moderate-sized plants having ample boiler capacity operating at moderate ratings, and not requiring additional capacity; third, industrial plants of large and moderate size, requiring additional boiler capacity, where the labor may be materially reduced by stokers; fourth, central stations or plants having the characteristic load curve of such stations.

Adaptability of Stokers to Different Requirements

In the first class of plants stokers are not, as a rule, adaptable to low-pressure boilers because of the fact that power is required to drive the stokers; and no saving in labor is possible, nor can stokers usually be installed except at considerable expense for changing the boiler setting or lowering the floor to secure sufficient height or distance between fire and shell or tubes of boiler. This latter condition also applies to high-pressure plants of similar character.

In the second class, the use of stokers would depend on the labor and coal saving possible. The load conditions and the coal available will determine the type of stoker. For steady, moderate loads and high-ash coal, the chain grate will be satisfactory; for some load conditions and good coal, the overfeed type. The underfeed type would also be satisfactory under most conditions, particularly where the coal is likely to vary in quality from time to time.

For plants falling in the third class, the forced-draft underfeed stoker will generally be found to be the most satisfactory because of its great flexibility, overload capacity and high furnace efficiency over a wide capacity range. This type of stoker will handle practically all coals between and including semi-anthracite and sub-bituminous with an ash content up to 15 per cent, and, except for high continuous overloads, 20 per cent.

For free-burning coal of higher ash content than 20 per cent, the forced-draft traveling grate would be a satisfactory

[1] Chief Engineer, Combustion Engineering Corporation, New York City. Mem.Am.Soc.M.E.

equipment, assuming that adequate provision is made to handle the ash.

Central stations and similar plants in the fourth class are practically forced to use underfeed stokers. Because of the low load factor of such plants it is essential that the stokers be able to force the boilers up to high overloads, 250 to 300 per cent of their rating for the comparatively short peak loads. It is also necessary at times to meet extraordinary loads with but little warning, and for this purpose the forced-draft underfeed stoker, because of its elasticity, is not equaled by any other stoker.

Starting from a banked fire with an underfeed stoker, it is possible to bring a boiler up to 200 per cent of rating in from four to six minutes, a performance not possible with any other type of stoker.

Where the coal has a high ash content and is of low heating value, it may be advisable to use traveling grates with forced draft. Sufficient grate surface can usually be provided to take care of the required overloads. This type does not respond as quickly as the underfeed type to sudden load changes, but where peak loads occur at certain known times they can readily meet such conditions.

So far the fuels considered have been those between and including semi-anthracite and sub-bituminous.

The successful use of mechanical stokers for burning the finer or steam sizes of anthracite is a comparatively recent development, and the writer considers himself fortunate in having been closely associated with this development. These fuels and coke breeze are now burned successfully on a traveling-grate stoker with forced draft. This stoker is the development of the work and experiments of the late Eckley B. Coxe, a prominent anthracite-coal operator. Many boilers equipped with these stokers and burning No. 3 buckwheat coal or coke breeze are being operated at from 150 to 200 per cent of rating. Because of the cost of the equipment it is not usually advisable to install in small plants or small boilers where only moderate loads are required.

This type of stoker is not as elastic as the underfeed, but is more so than the natural-draft chain grate. It would probably not meet satisfactorily the conditions of violently fluctuating loads.

Some recent experiments on this stoker have indicated the possibility of burning as high as 60 lb. of soft coal per square foot of grate, and in the near future there will be more data available on the burning of Illinois coal and lignite on this grate.

In existing plants among the principal limiting conditions found are the setting heights of boilers, the capacity of the breechings and stacks, the overload requirements, the kind of coal, the class of labor and the cost of the installation, and the foregoing classification of plants is only an attempt to generalize.

THOMAS A. MARSH.[1] The two general classifications of fuel from the standpoint of adaptability to stokers are: (1) coking and non-coking; (2) clinkering or non-clinkering. Compared with these characteristics all other properties sink into insignificance, as every experienced fuel burner knows. The writer would therefore discuss the stokers suitable for each of these classifications.

Coking coal is coal whose tars fuse at a temperature below their distillation point, resulting in binding the fuel together in a caked mass. Obviously, such a fuel-bed condition must either not be allowed to occur or it must be broken up soon after occurring. Stokers suitable to such fuels are underfeeds, inclined stokers similar to Murphy stokers, Roneys, L-type chain grates, Type E stokers. Almost all such fuels are found east of Pittsburgh, although some coking fuels are found in a few western sections.

[1] Engineer, Green Engineering Co., Chicago. Mem.Am.Soc.M.E.

LOCATION OF NON-COKING COALS

Non-coking coals are those whose tars distill off at a temperature below their fusing point. Such coals are, therefore, obviously free burning. The chain grate is well suited to these coals. The performance of the Commonwealth Edison Co. of Chicago is well-known and striking evidence of this

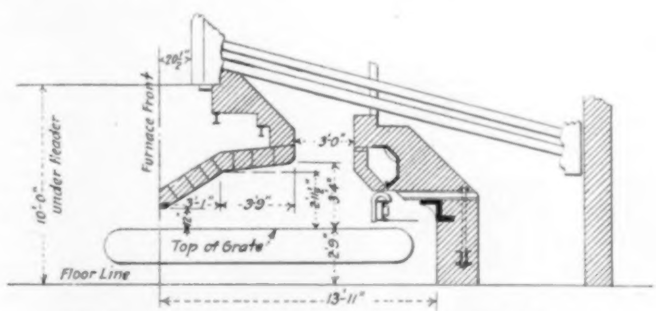

FIG. 12 CHAIN-GRATE SETTING—B. & W. TYPE BOILER

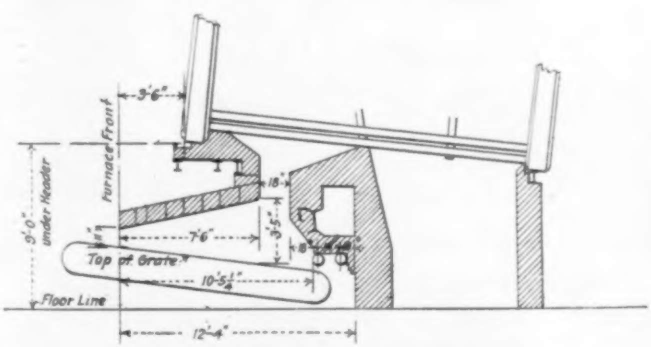

FIG. 13 INCLINED CHAIN-GRATE SETTING

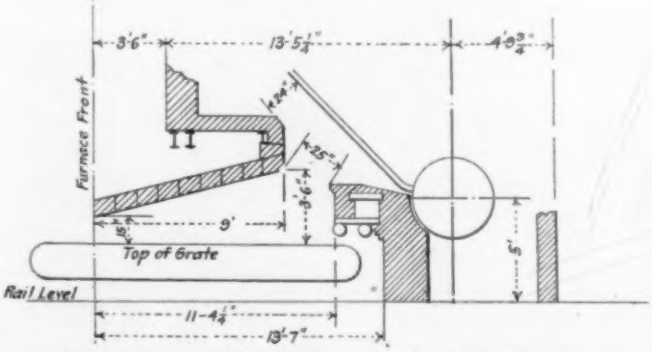

FIG. 14 CHAIN-GRATE SETTING—STERLING BOILER

fact. Such fuels comprise most of the fuels of Ohio, Illinois, Indiana, Iowa and in general all coals west of Pittsburgh. Those types of stokers which do not agitate the fuel bed give best results when the coal is free burning. A characteristic of such fuels is the minimum of operating attention necessary and the uniformity of results obtainable with minimum attention. Bituminous coals above described are being burned to 14 per cent CO_2 with 3 to 5 per cent ashpit loss. Combustion rates of 30 to 50 per sq. ft. per hr.

Clinkering coals are those whose ash fuses at or below 2500 deg. fahr. Such fuels must be handled on stokers which clear themselves of ash continuously. If the coal in question is a coking coal, the fuel bed should be agitated. If, on the other hand, the coal is free burning, the fuel bed should not be agitated, as this simply aggravates the clinker trouble.

The work of the late J. P. Sparrow has been particularly helpful in aiding in the selection of suitable coals for certain stokers where a choice of coals is possible and a selection of suitable stokers for the available coal where a coal selection is not possible. Mr. Sparrow's tabulation of a variety of coals as presented before the National Electric Light Association in 1916 is given in Table 8.

Suitable stokers for coal that cokes and also clinkers are Green "L" type, Murphy, Model and Detroit.

Suitable stokers for free-burning clinkering coal include all chain grates and traveling-bar stokers. The argument is very strong, due to higher operating efficiencies, low labor cost and low maintenance cost against the reverse if agitating stokers are selected.

Suitable stokers for coking, non-clinkering coals are: Underfeeds, "L" type chain grates, Murphy, Model, Detroit and similar agitating grates. Such coals are New River, Pocahontas and the better-grade eastern fuels.

These are broad classifications. Local operating conditions may occasionally indicate exceptions to these selections. The

TABLE 8 COALS SUITABLE FOR VARIOUS TYPES OF STOKERS

LOCATION OF MINE.	ANALYSIS							TYPE OF STOKER	REMARKS.
	MOISTURE	VOLATILE MATTER	FIXED CARBON	ASH	SULPHUR	B.T.U.	FUSION TEMP. °F.		
Cambria Co., Pa.	3.6	20.3	68.6	7.5	1.88	13710	2179		Very bad Clinkers.
Fulton County, Ill.	15.0	33.1	36.8	15.1	2.82	9880	2184		Clinker Trouble at Dump Grate, side Wall protected by Steam Jets.
Westmoreland Co., Pa.	2.2	35.2	50.0	12.6	2.37	12419	2223		Bad Clinkers.
Raleigh Co., W. Va.	4.2	19.9	70.8	5.1	0.88	14019	2295		Some Trouble with Clinkering and bridging over Dump Grates.
Borderland, W. Va.	7.8	35.9	49.8	6.7	1.15	12647	2297		Forms small Brittle Clinkers.
Raleigh Co., W. Va.	2.8	17.9	72.5	6.8	0.92	13889	2303		Trouble with Clinkers Bridging Dump Plates and on Side Walls
Caryville, Tenn.	4.0	33.6	47.4	15.0	1.57	11605	2304		Hard Clinkers.
Raleigh Co., W. Va.	4.4	17.5	70.9	7.2	0.85	13482	2306		Very Large Clinkers on Side and Bridge Walls.
Cambria Co., Pa.	1.8	25.3	64.7	8.2	1.36	13795	2335		Some Trouble from Clinkers.
Cambria Co., Pa.	2.6	19.5	69.8	8.1	1.92	13837	2361		Very Bad Clinkers.
Westmoreland Co., Pa.	2.6	35.0	51.7	10.7	1.87	12713	2384		Bad Clinkers.
Mercer Co., Pa.	5.4	34.0	47.5	13.1	3.40	12291	2390	Taylor	No serious Clinker Trouble.
Glen White, W. Va.	2.4	17.7	73.6	6.3	0.72	14112	2394		No Clinker Trouble.
Pocahontas	4.2	17.6	72.1	6.1	0.66	13918	2405		No Clinker Trouble.
Fayette & Raleigh Co., W. Va.	1.4	22.2	71.6	4.7	1.11	14565	2408		Large Clinkers on Side and Bridge Walls.
Somerset Co., Pa.	1.0	17.7	70.5	10.8	2.14	13689	2414		Good Coking, Free Burning, Forms Large Vitreous Clinkers.
Pittsburgh District	2.4	32.4	54.3	10.9	1.80	13006	2427		Very Little Trouble with Clinkers
Cambridge, Ohio	5.0	37.7	49.3	8.0	2.75	12521	2435		Forms Thin Brittle Clinkers.
Somerset Co., Pa.	0.6	17.8	71.6	10.0	1.88	13601	2468		Forms Large Clinkers.
Cambria Co., Pa.	2.2	25.4	63.2	9.2	2.67	13603	2534		Slight Clinker Trouble above 200% Rating
	1.5	22.4	69.5	6.6	1.87	14232	2584		No Clinker Trouble.
Glen Richie, Clearfield Co., Pa.	2.1	24.1	64.8	9.0	1.91	13480	2661		No Trouble.
Cambria Co., Pa.	1.6	25.4	65.5	7.5	1.36	14022	2684		No Clinker Trouble.
Washington Co., Allegheny Co., Pa.	0.3	32.2	57.1	10.4	1.06	13282	2290	New Roney	Bad Clinkers.
Washington Co., Pa.	3.7	27.7	56.2	12.4	1.45	12540	2363		" "
Rock Springs, Wyo.	4.8	35.8	46.3	13.1	1.54	11085	2239		Very Thin Soft Clinker, gives serious Trouble
	2.6	23.4	66.4	7.6	1.75	13928	2379		
Barnsboro, Cambria Co., Pa.	2.6	24.1	63.5	9.8	1.61	13414	2430	Roney	Clinkers part of the Time.
	3.2	22.7	66.0	8.1	1.95	13658	2444		
Glen Richie, Clearfield Co., Pa.	2.1	24.1	64.8	9.0	1.91	13480	2661		No Trouble.
Barnsboro,	2.6	23.4	66.4	7.6	1.75	13928	2379		
Cambria Co., Pa.	2.6	24.1	63.5	9.8	1.61	13414	2430	Westinghouse	Clinkers part of the Time.
	3.2	22.7	66.0	8.1	1.95	13658	2444	Under Feed	
Westmoreland Co., Pa.	2.2	35.2	50.0	12.6	2.37	12419	2223		Bad Clinkers.
	2.6	35.0	51.7	10.7	1.87	12713	2384	Riley	" "
Glen Richie, Clearfield Co., Pa.	2.1	24.1	64.8	9.0	1.91	13480	2661		No Trouble.
Washington Co., Pa.	0.3	32.2	57.1	10.4	1.06	13282	2290		Bad Clinkers.
Allegheny Co., Pa.	4.0	32.3	52.3	11.4	1.40	12604	2366	New Murphy	Only a Little Trouble from Clinkers.
West Virginia.	1.4	18.5	74.6	5.5	0.84	14483	2339		Clinkering Fair - 68.4% Eff. - Furnace Temp. 2400° to 2450° Fahr
Fayette Co., W. Va.	1.2	17.6	75.2	6.0	0.64	14387	2471	Murphy	Very Little Clinker-65.8% Eff. - " " 2100° to 2400° "
Wood Co., W. Va.	1.4	33.3	58.2	7.1	0.55	13651	2800		Good, no Clinkers-71.1% Eff. - " " 2325° to 2450° "
Illinois.	8.8	34.0	39.4	17.8	3.10	10231	2052		Lots of Clinker, but very Little Trouble.
Madison Co., Ill.	12.0	33.0	39.4	15.6	4.36	10145	2091		
Illinois.	9.8	34.4	39.1	17.7	5.11	10193	2157		
Christian Co., Ill.	13.6	30.9	37.8	17.8	5.04	9662	2179		Plenty of Clinkers, but no Trouble - 700 Hp. Maximum.
Sangamon Co., Ill.	14.2	31.4	38.9	15.5	4.40	9718	2179		" " " " " " - 800 " "
Illinois.	6.0	35.2	46.7	12.1	1.98	11689	2253		Lots of Clinkers but very Little Trouble.
Vigo Co., Ind.	10.2	33.8	38.4	17.6	3.99	10291	2256	Chain Grate	Plenty of Clinkers, but no Trouble. - 800 Hp. Maximum.
St. Clair Co., Ill.	10.8	33.4	37.9	17.9	5.04	9910	2291		Lots of Clinkers, but no Trouble.
Saline Co., Ill.	6.9	31.9	50.6	10.8	3.36	12020	2297		Plenty of Clinkers, but no Trouble - 800 Hp. Maximum.
	2.6	23.4	66.4	7.6	1.75	13928	2379		
Cambria Co., Pa., Barnsboro.	2.6	24.1	63.5	9.8	1.61	13414	2430		Clinkers part of Time.
	3.2	22.7	66.0	8.1	1.95	13658	2444		
Carthage, N.M.	1.2	37.3	45.6	15.9	1.01	12135	2599		No Clinker Trouble.
	1.2	20.8	69.3	9.7	2.48	13803	2468		
Cambria Co., Pa.	1.6	23.8	66.6	8.0	1.87	13989	2541		No Clinker Trouble.
	1.4	22.5	67.3	8.8	2.05	13806	2570	Hand Fired	
Somerset Co., Pa.	2.6	16.3	71.2	9.9	1.25	13428	2547		
	2.4	16.4	70.6	10.6	1.57	13269	2577		

The ash of most of the middle-west and western coals fuses from 2000 to 2400 deg. fahr. and some as low as 1800 deg. Clinker accumulations must be avoided. There are two methods of doing this. One is not to make the clinker, which necessitates that the ash be kept on the lower stratum of the fuel bed and out of the high temperature zone; the fuel bed must be undisturbed. The other method is to have a continuous discharge of the ash from the furnace.

The chain grate, which embodies both of these principles of keeping the ash in the low-temperature stratum of the fuel bed and of discharging the ash continuously from the furnace, is suited to coals of the northern interior, eastern interior, Gulf, western interior, southern and Rocky Mountain fields.

one feature of being able to get steam quickly in case of a water-power shutdown would sometimes offset almost any difficulty with clinker and the resultant low operating efficiency.

We should not in our entire discussion of this problem lose sight of the commercial aspects of labor saving, ease of operation and maintenance of furnaces and continuity of service when stokers are using unsuitable fuels.

CARL SMERLING. The hand-operated stoker is now installed in all types of furnaces and almost every type of boiler from 40 to 600 hp. in one unit, and to the extent of 5000 hp. in one fireroom. This stoker could well be named

the Ford of stokers or more closely nicknamed the "Jitney."

I have no reason to believe that the hand stoker will ever be adopted or used extensively in any large power plant or central station, but believe that its place belongs in the smaller units of 500 hp. and below. These stokers are now in use under oil stills, oil-cracking furnaces for the production of gasoline, acid furnaces, in concentration furnaces, hot-mill and annealing furnaces.

The principal objects of this stoker are to obtain a more universal and complete combustion, increasing the efficiency of the boiler, and to reduce labor, thus eliminating carelessness on the part of the fireman, which is accomplished in doing away with the cleaning of fires by the old method, and by the coking method in which the coal is piled high in front of the fire doors.

Sifting out the ash from the clinkers finally deposits approximately 5 to 8 per cent of the total ash in clinkers at the bridge wall on the dump grate, where it is dropped at regular intervals as required. If red coke falls through the grate, it is an indication that the fireman must not pull the levers more but wait until the ashpit again looks a little dark. This pulling of levers as a rule requires one pull of each lever every half-hour, and on the average coal of 12 per cent ash the dump grate should be dropped once in 8 hr. After continuing this operation, it is possible to run water-tube boilers up to 225 per cent rating without difficulty, provided sufficient stack and correct flues are installed; at 175 per cent rating it is not unusual to obtain 72 per cent combined efficiency and a continuous high CO_2 of an average of 13 per cent.

One of the most interesting features of this "Jitney" stoker is the fact that the first cost of installation is very low compared with the saving over that of hand-fired flat or shaking grates.

ROBERT H. KUSS contributes the data given in Table 9 on the types of plants and qualities of coal for which stokers of different types are adapted.

TABLE 9 COALS AND PLANTS TO WHICH VARIOUS STOKERS ARE ADAPTED

Type of Stoker	Minimum size of unit	Minimum plant, hp.	Maximum size of unit	Best coal characteristics	Unfit coal
Traveling grates	200 hp.	600	600 hp.	High volatile	Coking and low ash
Underfeed, Jones	150 hp.	300	300 hp.	Medium volatile	High ash, low-fusing ash
Combustion Engrg. Corp., Type E.	150 hp.	300	250 hp.	Medium volatile	High ash, low-fusing ash
Single incline	200 hp.	600	400 hp.	High fixed carbon	Low-fusing ash
Double incline	200 hp.	400	350 hp.	Medium volatile	Low-fusing ash
Inclined underfeed	500 hp.	200 0	Any larger size	High fixed carbon	Low-fusing ash

P. W. THOMAS. The stoker is restricted to a coal containing an ash which it will scavenge cleanly and without injury to its own metal. This brings a sharp division in the present types of stokers. Where the coal fluxes its ash at furnace temperature, a chain grate will invariably give the highest operating efficiency. Where the ash content is under 5 per cent or when the ash content will not flux at a temperature above 2600 deg. fahr., other types of stokers will give the same efficiency if properly handled.

The limiting factor in the use of the stoker in small plants is the cost of labor.

There is no *type* of fuel in the United States. Each field and each coal-producing district has absolutely individual fuel. The only comparison by analysis of the various fuels must be that analysis which shows, in addition to the usual proximate analysis, the quantitative analysis of the ash and its fluxing temperature. Given these figures, it is a matter of simple calculation to know which of the many stokers would perform so as to obtain the greatest percentage of heat to the boiler.

By the above let me explain that two bituminous coals showing the same proximate analysis may have entirely different ash contents, entirely different coking properties and attendantly different combustion rates. They both require the same quantity of air in the consumption of a pound of coal, but no device will cause one coal to unite with its given quantity of air in a shorter interval of time than its nature allows. The flexibility of a stoker, then, depends on how many pounds of coal can be supplied with the proper amount of air at one and the same time. Two methods are open: to increase the grate surface, or thicken the fire and apply the forced draft. In the latter case it is again necessary to figure the fluxing temperature of the ash in incandescent coke.

WALTER E. BRYAN. It has been common practice with Illinois fuel, where mechanical stokers are desired, to use chain grates. These give very satisfactory results, except that they cannot be forced to any great extent. Underfeed stokers should have a little larger size of coal, and also coal freer from impurities than that required for the chain grates. Stokers of the Westinghouse type have recently been used in this district on bituminous screenings with great success.

B. J. DENMAN. The chain-grate stoker is best adapted to coals containing 25 per cent or more of ash, due to the facility with which it disposes of the refuse. This is one of its chief advantages, and in addition to this it is one of the cheapest stokers available, and undoubtedly has the lowest cost of maintenance. From the operating standpoint, the chief objections to the chain-grate stoker are its lack of responsiveness and the fact that its point of best efficiency is rather sharply marked, dropping off somewhat rapidly at overloads and very rapidly at light loads. With proper care, good efficiencies can be maintained within a reasonable range of capacity, the low percentage of CO_2 which is obtained in most plants being unnecessary. The chain-grate stoker is practically smokeless. To secure the best results it should be set with flat coking and boiler arches of an inclination and length to best suit the fuel burned. This stoker is suitable for non-coking coals only. With coking coals it is impossible to get reasonable capacity, and the ash is practically pure coke. Chain grates which have been designed to burn coking coals have not been found to be successful.

The inclined overfeed type of stoker has the advantage of reasonably low cost but the disadvantage of high maintenance. Most stokers of this type require frequent poking of the fires, which produces considerable smoke. These stokers are not suitable for coals containing over 15 per cent of ash. They have a limited range of capacity, but are quite responsive to change in loads.

The inclined underfeed type of stoker has the greatest range

of capacity, the best efficiency of any stoker available, and the additional advantage that it is the most responsive to changes in load. Boilers can be raised from bank fire to steaming at the rate of 200 per cent in less than five minutes. This type of stoker has an unusually flat efficiency curve, with a high efficiency throughout the range, and with most arrangement of settings the highest efficiency is at light loads. This applies particularly to coal averaging about 14,000 B.t.u. and from 6 to 8 per cent ash. This enables a plant having evening peaks to eliminate the carrying of banked fires to meet the peak load, as it is possible to install sufficient stoker capacity to secure a boiler rating of 300 per cent.

The chief disadvantage of this type of stoker is its high first cost, but this is offset by the high capacities possible, which reduce the boiler-room investment. It is, of course, undesirable to operate the boilers at such high rating except for short periods, and for plants having no short peaks it would be uneconomical to put in sufficient stoker capacity to obtain these peaks. It has been my experience that considerably higher combined boiler and furnace efficiency can be obtained with this type of stoker than with any other type, and I have made extensive tests with chain-grate, inclined overfeed, and inclined underfeed stokers. This stoker is suitable for coals having as high as 20 per cent ash, but with coals running this high in ash, and with heating value as low as 10,000 B.t.u. per lb., it is necessary to arrange dumping sections of about twice the length normally provided, and to increase the height of the stoker sufficiently beyond the amount usually required, if very high rating is desired. We are carrying loads as high as 300 per cent rating with Illinois coal averaging about 10,500 B.t.u., with 15 per cent ash. The maintenance of this type of stoker is low as at present designed. This stoker is suitable for either coking or non-coking coals.

I do not believe the size of the plant determines whether or not a stoker should be used. This is more a question of labor conditions, load factor and funds available. We are at present operating a plant containing three 500-hp. boilers, hand-fired, while in an adjoining city of practically the same size we found it advantageous to install stokers. In that same city we are operating a gas plant containing two 200-hp. boilers, only one of which is in use at a time, which we have equipped with stokers.

A. H. Blackburn.[1] For the large electric-power plants with wide ranges of coal, and the larger manufacturing plants with boiler units from 500 to 2500 hp., the underfeed gravity and underfeed direct-push, self-cleaning stokers are the types of stokers best adapted, because they respond most quickly to the varying coals. They will show high efficiency for a range of from 80 to 200 per cent of rating. They will raise steam from no load to 200 per cent in a few minutes and are practically smokeless. They will successfully burn Pennsylvania, Maryland, Virginia, Ohio, Kentucky and Michigan coals.

The chain grates show best results when working at a steady load. They are adapted to free-burning coal high in volatile such as the coals mined in the Middle West; they are not so suitable for the coking coals having high fixed carbon.

The overfeed, inclined-grate and the side-feed stokers are adapted to boilers from 150 to 300 hp., and obtain their best economy when working from 80 to 100 per cent of rating and are not suited to heavy overloads.

The underfeed stokers and the combination of underfeed and overfeed stokers are suitable for boilers from 150 to 500 hp. and show excellent efficiencies at ratings from 80 to 150 per cent and can be worked up to loads of 200 per cent. The advantage of these stokers is the rapidity with which they will take care of sudden variations in load, the average good efficiencies obtained, and the comparatively low cost of repairs. They will successfully burn coals from Illinois, Kentucky, Ohio, Pennsylvania, Maryland, West Virginia, Iowa and Michigan. For internally fired Scotch marine boilers and internally fired vertical boilers of the Manning type the underfeed stoker has been successfully applied, showing results of 10 per cent saving over hand firing.

For the fair grades of lignite coals of the West, the underfeed stoker is being used with considerable success, especially when the fuel comes directly from the mine and before it dries out, by running light fires and rapid combustion.

As to the limiting factor in the use of mechanical stokers in small plants: Stokers can be applied with good results to boilers as low as 100 hp., especially when there is only one man employed to look after the boiler, engine and other apparatus about the plant, as hoppers can be put on that will hold an hour's supply of coal, or more; the automatic regulation will take care of the steam or combustion rate while the attendant is looking after other work.

Will Successfully Burn Green Lignite

Stokers have too often been applied under unsuitable conditions. Proper consideration has not been given to combustion space, the size of the unit and the particular design of the boiler to which the stoker has to be applied. The time has come when the first consideration must be given to proper design of combustion area to the particular quality of coal to be burned, and to the installation of boiler and stoker designs best suited to this condition.

[1] Chief Engineer, Under Feed Stoker Co. of America, Chicago. Mem. Am.Soc.M.E.

8 What Experience Have You Had in the Use of Wood as Fuel? To What Extent Is Wood Available as a Fuel?

The coal shortage has occasioned the use of wood fuel in many unwonted places. Accounts of experience that will be helpful are solicited.

Robert H. Kuss. The writer's experience includes the burning of wood refuse coming from kiln-dried manufacturing operations of both hard and soft wood and "hog stuff" produced at logging mills in northern Minnesota. Kiln-dried wood refuse when burned alone constitutes no particularly difficult problem. If a sizable proportion is sawdust or planer shavings this material must be burned in a complete firebrick furnace, the fuel being introduced by gravity, and most of it being burned in suspension with very little air from the ashpit.

Where coal and wood refuse are burned together, difficulty is encountered if the major portion of the fuel is sawdust. Planer shavings in large quantities set up extremely difficult conditions. In any event, the combination of fuels must be

burned in a complete firebrick furnace, so that the sawdust portion may be burned in suspension.

When "hog stuff" is produced from bark, edgings, etc. (as is the case in lumber-producing mills), it is best burned in a complete firebrick furnace where the fuel is introduced so as to form cone heaps over the grate surface, very little air being introduced by way of the ashpit, and the fire being most brisk at the grate surface around the edges of the cones.

ALBERT A. CARY. I have had to handle wood as a fuel under a wide variety of conditions which have called for different constructions in furnaces, as wood from a lumber camp, where undesirable tree trunks, boughs and branches were burned; in saw mills where the fuel was slabs, edgings and sawdust; in wood-pulp mills where the wood refuse was burned; in woodworking establishments where the fuel was the refuse from the saws, planers and other wood-working tools.

It must be remembered that fully one-half the weight of the wood is found in the volatile gases passing off during the process of combustion. With properly designed furnaces, the greater part of the air required for the combustion of these gases can be made to pass through the grates and fuel bed, where they become warmed to such an extent that they will not suppress the combustion of the gaseous portion of the fuel in the combustion chamber. An ample and well-designed combustion chamber is also essential to obtain efficient results.

Two objections commonly offered to the use of wood fuel are the production of objectionable smoke and danger from fire due to burning firebrands ejected from the chimney. With a properly designed and operated wood-burning furnace, however, the smoke nuisance can be so reduced as hardly to constitute a nuisance, and I have found no difficulty in stopping the trouble from sparks and hot cinders by using cinder screens enclosing the top of the chimney.

Heating Value of Wood Fuel

In the boiler-test code of the Society we have been instructed to regard 1 lb. of wood as equivalent to 0.4 lb. of coal; or, in other words, $2\frac{1}{2}$ lb. of wood are equivalent to 1 lb. of coal.

The value of *dry* wood used as a fuel may be slightly greater or considerably less than this equivalent of bituminous coal, according to the design of furnace used and the manner in which the fire bed and its air supply are handled. The percentage of moisture carried materially affects the heating value of wood fuel, and therefore it is most desirable to have the wood as dry as possible.

Wet fuel, however, must often be used, and I have burned pulp-wood chips or shavings running as high as 30 to 40 per cent in moisture. Such very wet wood fuel must be burned in a reverberatory furnace with a heavy bed of burning fuel maintained, to dry the moist wood rapidly as it is fed continuously into the furnace.

Newly cut wood contains a large percentage of moisture, which varies in the different varieties of wood, but from one-third to one-half of this moisture will disappear if the wood is air-dried from six to twelve months.

Examples of Successful Wood-Burning Furnaces

In burning forest wood such as trunks, boughs and branches, I have found that much better results could be obtained with a wide furnace than with a long, narrow furnace in which wood is charged lengthwise through a front opening. With the long furnace it is difficult to maintain a good level fuel bed and have the grates evenly covered. I have obtained the best results for such fuel with a furnace about 5 ft. wide and 7 ft. deep. This had a charging door, running across the width of the furnace and about 12 in. high, which lifted vertically above the dead plate along the outer face of the front wall, being counterweighted and properly balanced, and the door was perforated with a number of $\frac{1}{2}$-in. holes to admit and evenly distribute small streams of air over the fire bed.

The cut lumber was piled in front of the door so that it lay lengthwise, running from one side wall to the other. When the door was lifted the lumber, thus arranged, was pushed over the dead plate on to a grid of sloping grate bars dropping downward at an angle of about 30 deg. At the lower end of these sloping grates and about 18 in. from the bridge wall, I arranged another grid of sloping bars, dropping down from the bridge wall at an angle of 45 deg., thus forming a V-shaped grate surface having a long and short leg.

With this arrangement, the lumber was rolled or shoved down the bars from the dead plate in such a manner as to maintain a fairly thick and more or less compact fire bed over the lowest position formed by these sloping grates and very little difficulty was found in keeping the upper end of the grates (nearest to the door) covered with fuel. The charging door was kept open for the shortest possible time.

I designed and installed some very successful furnaces, built on the same general lines, for a large manufacturer of wooden cars, near Buffalo. The grates (under water-tube boilers) were placed a short distance above the floor level, thus obtaining a very high combustion chamber. An ashpit was excavated about 24 in. below the floor level with a trench along the outer face of the boiler fronts through which air entered. This trench was covered with removable plates in front of each of the large lifting, charging doors to permit easy cleaning of the ashpits.

The refuse from the woodworking shops was delivered to the boiler room through chutes and consisted of large and small pieces, chips, shavings and sawdust. The fireman piled the refuse in front of the upward-sliding doors, which were balanced in order to operate easily. When the doors were opened the fuel was shoved in quickly upon the large flat grate surface and the doors immediately closed. Two boilers, of about 200 hp. each, were operated in this manner most successfully.

In another woodworking shop in the West, manufacturing furniture, I supervised the installation of another form of wood-burning furnace placed under water-tube boilers.

Here the boilers were set very high above the grate surface and the wood refuse was continuously spouted down tube-like pipes, shooting into the furnace directly through the boiler fronts and landing upon the fuel bed below. A supplementary fire of coal was maintained upon the grates, and thus the plant obtained an ample supply of steam.

I do not know who was the designer of this system, but I protested against its installation on account of danger from fire running back along the wood-conveying spouts. About two years afterwards this plant burned and there was some question raised as to whether or not the cause was due to this system of feeding wood refuse to the furnace.

I have designed and supervised the installation of several different forms of extension furnaces for burning wood refuse, which have given satisfaction. Some of these have their fuel charged through top openings in the covering arch, above the

grate bars. The principal defect in this type of furnace is the pyramiding of the fuel on the grates directly below the stoke holes. This can be overcome to a large extent by building up a grate construction under the stoke holes, shaped like a pyramid. This insured a good penetration of air throughout the entire fuel bed and did away largely with the poking necessary to free up the other form of fuel bed.

Grateless Furnace for Wood Burning

One of the most successful forms of wood-burning furnaces for woodworking shops that I have installed is a grateless furnace similar in its general form to the well-known beehive type of coke oven. It is circular in shape, with a semi-spherical, dome-like cover over the top. I owe my first conception of this type of furnace to my friend, the late F. W. Edwards of the Standard Oil Company, who was deeply interested in the study of furnace equipments.

In this furnace the refuse wood is first run through a disintegrator, consisting of a disk having heavy knives inserted near the circumference of one of its faces. This disk is revolved at a high rate of speed inside of a casing, the larger pieces of wood refuse being fed into the disk chamber.

Thus the size of the wood is reduced until it is small enough to be carried by an air blast through conducting tubes. The end of these conveying tubes terminate in a centrifugal separator head, where the greater part of the air used for flotation is discharged. The wood refuse is then dropped through a tube from the bottom of the separator, accompanied by air under sufficient pressure to project the fuel into the furnace.

The wood passes into the furnace in a tangential direction, which causes it to travel around the circular face of the round furnace, and with the very high temperature maintained the wood ignites and burns very rapidly, somewhat after the manner in which pulverized coal is burned.

An opening, running in a normal or radial direction out of one side of the circular furnace, carries the burning gases directly into the firebox chambers of adjoining boiler settings.

A slowly burning fire bed of coal is maintained upon the grate bars of the boiler furnace and the combustible gases burn rapidly above this coal fire bed, without smoke production, and by this means the most efficient results are obtained from the wood refuse.

In case the supply of wood refuse gives out a damper is closed between the wood furnace and the boiler furnace and the boilers are operated in the regular manner with coal.

I have designed several variations in the construction of this type of furnace and in one case I fed wet spent licorice root down through the top of the furnace while operating the furnace proper in the way described above, with wood refuse from a large neighboring box shop.

A. G. Christie. At a recent meeting of the Baltimore Section of the Society, Mr. Henry Adams stated that he had burned wood on several occasions in furnaces designed to use soft coal and had obtained satisfactory results. However, only about 60 per cent of the rated boiler capacity could be obtained under average conditions. Another local member stated that he had found it advisable to lower the bridge walls when using wood in furnaces designed for coal.

9 What Coal Economies Can Be Effected in Residence Heating?

He who could make one ton of coal do the work of two during the past winter, not only conserved the coal for his neighbor and saved his own money but was comfortable when he might have otherwise been cold. How can it be done?

Frank T. Chapman.[1] According to good authority approximately 120,000,000 tons (2000 lb.) of coal is the present rate of use per year for domestic purposes in the United States. No accurate record exists to indicate what proportion of this coal is used for residence-heating purposes, but probably at least two-thirds, or 80,000,000 tons, of this amount is used for what might be broadly stated as residence heating.

The possible saving in coal used for residence heating may be divided into five principal items as follows:

1 Elimination of Heating for Unnecessary Rooms and Buildings:

a Shutting heat off from rooms not actually needed

b Closing of large residences where heating requirement is unreasonable for number of occupants or the rearrangement of heating equipment in order to heat only the portion of house actually needed for occupancy. (This item should represent a saving of at least 10 per cent.)

2 Lower Temperature Maintained in Homes:

a A 5 deg. lower average than past practice would save about 10 per cent of the fuel requirement.

3 Observance of Practical Methods of Reducing Preventable Heat Losses:

a Insulation of cellar piping, heater or other sources of heat loss

b Prevention of undue leakage at windows and doors.

4 Economical Operation of Heating Apparatus:

a The keeping of gas passages of heaters clean. (By far the most vital factor and the most important to emphasize.)

b Proper draft regulation

c Sifting ashes where they contain fuel value

d The study and application of available war coal-saving rules. (This item No. 4 should represent a possible saving of 20 per cent.)

5 The Use Where Available of Substitutes for Coal as Fuel, such as natural gas, kerosene oil, fuel oil, wood, peat.

A summary of these possible savings totals a proportion of about 50 per cent of the coal now used for residence heating. For practical calculation let us assume that one-half this proportion, or 25 per cent of the saving, can actually be effected, provided proper means are used to inspire, educate and require the public to take a more personal interest in conserving coal. Based upon 80,000,000 tons, 25 per cent would mean a

[1] Eastern Manager, American Radiator Company, New York. Mem. Am.Soc.M.E.

saving of 20,000,000 tons in residence-heating work, to which could undoubtedly be added a goodly percentage of coal now used for domestic cooking and hot-water service, by increased economy in its use and by a more extensive substitution of other fuels for cooking.

The practical possible saving on all domestic uses of coal would, therefore, appear to lie somewhere between 20 and 30 million tons. It is important to note that in this 25 per cent saving, only 10 per cent is figured as secured from "economy of operation," the remainder being mainly by elimination and lower maintained temperatures.

Having visualized the first two phases of the subject question, we come to the third phase, viz., the method of procedure that will bring about the greatest conservation. This phase is only indirectly covered by the original subject but is the vital factor which governs the proportion of the possible economies that can be effected.

An active educational program with punch and compulsion in it, as well as an appeal to patriotism, is required, and such a program must necessarily be based upon a plan of regulation and limitation of coal supply calculated upon quantities requiring economy. Only by such means can the average householder be aroused and impressed with the fact that if he does not study and apply the conservation rules, his negligence will react upon the comfort of his own family. He will run short of coal, while his neighbor who has observed the rules will have sufficient for his needs.

Information accumulated leads to the statement that a sufficiently consistent plan of apportioning coal for residence heating, cooking and hot-water service by regulation and limitation, can be secured to make the enforcement practical.

SAVING COAL IN HOT-AIR FURNACES

C. R. MUELLER.[1] In a residence of six rooms an estimated saving of 30 per cent of the coal was made last winter without any radical changes in the heating system. The installation consisted of an ordinary hot-air furnace using recirculated air. The means by which this saving was effected may be applied to practically all types of hot-air furnaces, to obtain as good and even better results.

One way of saving coal was to employ the alternate method of firing for the various poor grades of bituminous coal available. Instead of being spread over the whole surface, fresh charges of coal were thrown on one side of the fire only. The red coals left exposed on the other side ignited the gases distilled from the green coal, thereby saving the heat which ordinarily would have been wasted up the stack, in the form of unburned gas. Smoking was reduced and the usual explosion, which occurred just after firing, was prevented.

The fuel saving was further increased by lowering the room temperature below that required for comfort in ordinary residences. In residences where the humidity averages 20 per cent or less, during the heating season it is not comfortable unless the room temperature is at least 74 deg. By maintaining a relative humidity of 40 per cent a temperature of 68 deg. was found comfortable. In order to obtain this high humidity it was necessary to substitute for the regular water container pans with twice the evaporating surface, and set them close to the firepot. The pans were kept full by means of a float valve connected to the city water service. Since the amount of water evaporated was comparatively small, the coal consumed in this way was neglected in the following example.

[1] Detroit, Mich.

The calculation of the saving which resulted by operating at the lower temperature is based on the fact that the heat loss of a house is directly proportional to the difference in temperature between the inside and outside air. For this city (Detroit) the average outdoor temperature during the heating season is 37 deg. The difference between the inside and outside temperatures is 31 deg. for a house at 68 deg., and 37 deg. for one at 74 deg. The saving, then, by the comfortable house with 40 per cent humidity over the comfortable house with 20 per cent humidity is (37 deg.—31 deg.)/37 deg. or 19 per cent.

In addition to this economy there is, due to the increased humidity, a diminished susceptibility to colds and other pleural ailments.

Recirculating the air in a residence instead of drawing fresh air from outdoors results in a saving of coal, since less heat is expended in warming the inside air through the smaller temperature range. In regard to the healthfulness of recirculation, it can be no more objected to than in the case of steam-heated dwellings, which have no particular fresh-air inlet. Moreover, the air which leaks out of the cracks around the doors and windows is generally sufficient to supply many times more than the amount required for breathing.

The sluggish circulation encountered in the large majority of houses due to the poorly designed air ducts, results in a high stack temperature with its consequent waste of heat. A vigorous flow of air around the firepot and gas passages is necessary to take away this heat and carry it to the rooms above. Good combustion being maintained, the greatest saving of heat occurs when the stack temperature is reduced to the minimum required for draft. The writer made his largest saving during the past winter by using a 12-in. electric desk fan in the recirculating duct leading to the furnace. The fan was operated about fourteen hours daily, forcing twice as much air through the furnace as would have flowed naturally.

Several tests were made under various conditions, in all of which the superiority of forced circulation was obvious. In two consecutive 24-hr. tests, run to determine the economy of forced circulation, the results in Table 10 were obtained.

TABLE 10 TESTS OF HOT-AIR FURNACES

Kind of Circulation	TEST No. 1 Natural	TEST No. 2 Forced
Duration, hours	24	24[1]
Average temperatures, deg. fahr. difference, inside and outside	47	60
Average temperatures, deg. fahr. stack	309	205
Total lb. coal fired	106.5	78

[1] The fan was run only 17 hr. of the 24 hr. of the test.

Reducing the coal consumption for the conditions of the first test to those of the second based on the ratio of temperature difference, we have $106.5 \times (60/47) = 136$ lb. The coal saving was then $136 - 78 = 58$ lb., which, at ½ cent per lb., amounts to 29 cents. The cost of fan current at about ¼ cent per hour, or 4 cents for the test, makes the net daily saving 25 cents. The saving of coal expressed as a percentage was $100\ (136—78)\ /136 = 42.6$ per cent.

The few published results available on the performances of hot-air furnaces with forced circulation seem to agree to the extent that the efficiency is increased from 5 to 50 per cent by the use of a fan.

The means of saving coal in hot-air furnaces may be summarized thus:

a Alternate method of firing
b Maintenance of a room temperature of 68 deg. with humidity of 40 per cent
c Recirculation of air
d Reduction of stack temperature by forced circulation.

Philip J. Savage.[1] Probably the best method of recommending possible economies in residence heating is to summarize briefly some observations and experiences extending over a period of six years and made in connection with the operation of a warm-air generator of well-known make, installed in a ten-room solid brick residence with average general exposure. Anthracite fuel was used exclusively.

Coal in each of the following forms has been given a full heating season's trial: egg size alone, egg and stove size mixed in equal portions, and stove size alone. Experience indicated that the stove size or smaller coal produces a more compact fire bed, and has the advantage of uniformity of burning rate causing less loss in the ashes. There was no appreciable loss of unburned coal through the grates with the stove size and, in a furnace of proper size, it produces flexibility and burning speed sufficient for severe weather. Incidentally, the cost per ton is lower for the smaller size.

The proper method of operating the grate shakers or revolvers should be carefully studied and the furnace maker's instructions closely followed. Great economies are possible here, in the lack of waste in the ashes. The variation in practice with identical apparatus is remarkable.

The necessity for a check damper in the smoke pipe, for purposes of economy, is obvious. The smoke pipe and its connection to the chimney should be free of air leaks, as the draft-checking effect may necessitate opening, more or less, the damper in the direct draft, which in most furnaces is designed to cause the hot products of combustion to bypass this damper section and flow through heat-absorbing chambers before admission, indirectly, to the smoke pipe. In the residence referred to, the damper in the direct-draft path is left in the closed position at all times of normal operation, except when the fire is being shaken down, and when coal is being added.

The prevention of air leakage at fireplace or grate openings by means of dampers or folding screens, at night and at other times when the ventilating effect is not necessary, is also valuable as a heat saver. Means should be improvised to prevent the all-night loss of heat through the open windows of bedrooms whose doors are left open, for various reasons, to the rest of the house. Stairways can often be more or less completely blocked—by the use of a suitable folding screen, for example. In the residence in question, the morning temperature of the downstairs living rooms has been raised from around 60 deg., to 68 or 70 deg. by means of a screen placed nightly on a stairway, which effectively prevents the convection losses.

Relatively large areas of window and door exposure should be checked up very closely, as heat losses of great magnitude are occasioned by this means. The installation of weather strips on one door, and of storm windows on four large windows with severe exposure, in the residence referred to, effected very marked improvement.

The question of humidity does not seem to receive enough attention. The water pan in most of the hot-air installations, when present at all, is placed in the cold-air intake where the moisture absorption is almost negligible; and in installations of the hot-water or steam systems provision is seldom made for humidifying. At a nominal cost an efficient and automatic humidifying system can be installed in a hot-air furnace, with water pan in the dome above the firepot, where the moisture absorption is naturally greatest. Water pans, with some sort of simple wick arrangement to assist evaporation, placed beside the hot-air registers or over steam or hot-water radiators are appreciably helpful. In the installation under observation, a water pan in the air dome of the hot-air furnace and three pans, each with wick arrangement, placed beside floor registers, have increased the relative humidity during normal winter weather from an average of under 30 per cent to an average of about 45 per cent. An evaporation of over five gallons per day was secured.

By means of the changes above enumerated, in equipment and method of operation, the coal consumption in the residence referred to has been reduced from an established average of 16 tons per winter of average severity to 12 tons. The expense involved for the double windows, weather strips on a door, a new indoor air feed to the furnace and the humidifying apparatus was \$50, and it has been an exceedingly profitable investment, aside from the added comfort obtained.

[1] The Detroit Edison Company, Detroit, Mich.

Robert H. Kuss. The writer has found success, when using bituminous coal of the non-coking variety (Illinois or Indiana, prepared sizes) by employing the following methods:

1 Attempt to operate throughout the heating season with the same height of refuse and live-coal level, this being two or three inches above the level of the bottom of the charging-door opening in the usual equipment.

2 Prepare for a new firing by crowding the live coal to the place nearest the firepot-chamber gas outlet. If the gases rise vertically over the entire firepot area, there is no choice in the matter.

3 Charge the green coal into the depression which should extend down to the refuse, thus permitting no contact with live fuel except on the surface nearest the placement of the live coal.

4 Regulate adjustments in draft for the period of a day's run by means of the check damper; regulate the maximum and minimum heat delivery (depending upon the severity of the season) by means of the chimney damper. In other words, the check damper is the daily, and the chimney damper the seasonal, draft appliance.

5 Admit very little air over the fire.

6 As the demands for greater or less heat delivery occur, vary the thickness of the refuse from 3 in. for greatest requirements to only a small live-coal area about 6 in. deep for mildest weather.

7 To facilitate refuse removal from the place of greatest accumulation, disconnect the bars of the other grate sections from the shaking lever.

8 Shake grates very moderately.

The results have been found to be, when compared with usual practice:

a Decidedly less combustible in the refuse
b Decidedly less clinkering
c Decidedly less soot formation
d More uniform heat delivery
e Substantial economy increases in mild weather.

Donald B. Prentice.[1] The annual domestic coal consumption of the United States is estimated to be 1.1 tons per capita

[1] Assistant Professor of Mechanical Engineering, Lafayette College, Easton, Pa. Jun.Am.Soc.M.E.

of total population, and to be 1.4 tons per capita of those living in buildings heated by coal. These figures place the annual consumption for heating, excluding exhaust-steam installations, at 110,000,000 tons, including all grades of coal. If the average efficiency secured in boilers, furnaces and stoves can be raised from 45 to 55 per cent, for example, the same heating results will be produced with 90,000,000 tons. This reduction of 20,000,000 tons would decrease shipments by nearly 500,000 carloads, with an additional saving of fuel on the railroads. Under the present circumstances, of course, these 20,000,000 tons would be shipped as usual and diverted to industries where the need is severe, making an important contribution to relieve the industrial shortage.

Many residences are equipped with hot-water heating plants. A disadvantage of this system is the cooling of the large body of water during the night, and the consequent losses due to forced combustion in the morning, when an effort is made to raise the water temperature rapidly. The greatest cooling effect is felt in bedrooms, especially in children's rooms where windows are often open for twelve hours or more. All hot-water radiator valves when closed permit enough circulation to prevent freezing, which is necessary, but this circulation, unfortunately, is enough to reduce the temperature of the water in the entire system. The writer has found that closing bedroom radiator valves and then carefully wrapping the radiators with blankets will keep the temperature of the water in the system at least 60 deg. higher than it will be if the radiators are exposed to window drafts. If the water is at 140 deg. instead of at 80 deg. in the morning, fuel is saved and the living rooms are more comfortable.

On new installations with sectional boilers it is possible to have two distinct water systems, one for the living-room floor and one for other floors. This arrangement keeps the living-room circuit warm over night. It involves, however, considerably more piping and therefore adds to the cost.

The coefficient of heat loss from glass is four times that for the ordinary residence wall. If shades are drawn completely down after dark at all windows on the first floor and at all windows except those in bedrooms on other floors, and left down until morning, very valuable dead-air spaces are added to the glass areas, reducing the heat loss perhaps 50 per cent. This procedure also checks window leakage to some extent. Although living-room shades are usually drawn, the number of unshaded windows in most houses is surprising. Window shades are important factors in residence heating in another respect, the shutting out of sunlight. Part of the heating requirements of a residence can be met for many hours on sunny days by allowing the interior furnishings to absorb the radiant heat of the sun to the greatest extent possible.

A means of saving fuel in the furnace itself, which is not mentioned as often as it should be, is the use of small sizes of coal. It is quite practicable to burn anthracite as fine as No. 1 buckwheat on the ordinary shaking and dumping grate by carrying the fire on a bed of ashes, provided there is sufficient draft, which is usually true. This small coal, although higher in ash, can deliver as many heat units per pound as the larger sizes for three reasons: (1) For the same weight the coal has greater surface on which carbon oxidation can take place, which insures complete combustion; (2) the air passes through the fuel bed in fine streams and against enough resistance to keep the excess oxygen in the flue gas at a moderate amount; (3) the fire tends to spread over the whole grate quickly and without manipulation, which eliminates dead spots and prevents air leaks. These statements are not merely expressions of opinion, but conclusions from numerous tests.

Is it too much to expect of householders and amateur firemen that in the winter of 1918-19, by the use of small coal, by anticipating heating requirements and managing their fires accordingly, by eliminating or decreasing heat losses wherever possible, they will save the equivalent of at least one-fifth of the anticipated industrial shortage of 50,000,000 tons?

L. W. EGGLESTON.[1] The average rate of combustion in house-heating boilers is about 30 per cent of the rated capacity of the boiler. Most boilers develop their highest efficiency at their rated capacity, but to secure the most economical results the boiler should have its greatest efficiency at from 40 to 60 per cent of its load. All boilers designed for ascending gas travel are most efficient at high rates of combustion; under low rates of combustion there is not sufficient volume of gases to fill all of the flue space. The gases pass to the chimney by the shortest route without giving up all of their available energy.

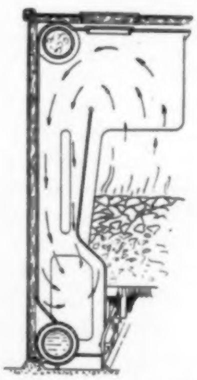

FIG. 15 PRINCIPLE OF CONSTRUCTION OF REVERTIBLE-FLUE HOUSE-HEATING BOILER

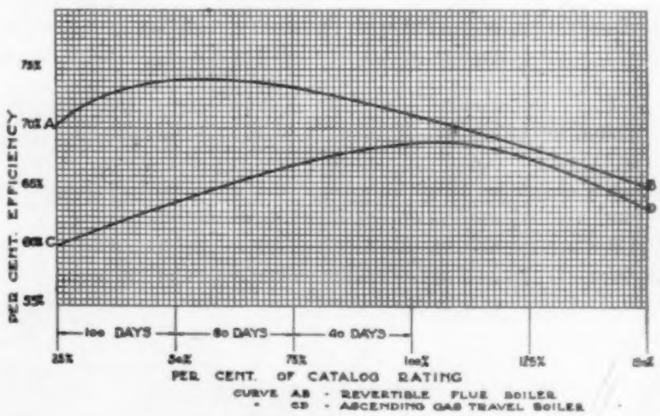

FIG. 16 COMPARATIVE EFFICIENCIES OF REVERTIBLE-FLUE AND ASCENDING-GAS-TRAVEL BOILERS

The most modern boiler construction is designed with a revertible flue travel, forcing the gases from their natural course. This feature properly applied to a boiler leaves no short cut for the gases to escape to the chimney. The floating effect of the gases while trying to resist the power of the chimney on their downward travel causes them to press against the heating surfaces of the boiler and give up their available heat under

[1] Manager, Sales Engineering Dept., American Radiator Co., Chicago, Ill.

all rates of combustion. This principle of construction is shown in Fig. 15.

Fig. 16 shows two efficiency curves. The lower curve shows the efficiency of a boiler with ascending gas travel. Its highest efficiency is at catalog rating. The upper curve indicates the efficiency of the revertible flue boiler, its greatest efficiency occurring at 50 per cent of catalog rating.

An important step in connection with a steam boiler is to free the system from oil and grease. Oily substances on the surface of the water in the boiler offer resistance to the generation of steam, producing an unsteady water line in the boiler and resulting in a wet-steam supply to the heating system. It has been frequently demonstrated that a greasy condition in a boiler has increased the fuel consumption more than 25 per cent and, unless the boiler is thoroughly cleaned after the plant is installed, the grease and oil will remain in the system indefinitely.

The most economical control for house-heating boilers is effected by allowing the greatest possible amount of the draft tension on the boiler at all times. The fire should be regulated by the draft door located in the ashpit. This door should be adjusted so that the maximum results can be obtained with the smallest possible amount of opening. With this control, excess air is prevented and good results are obtained at all rates of combustion. A great many operators imagine that by closing the choke damper in the smoke hood they prevent the heat from escaping up the chimney. This practice, however, decomposes the fuel without giving off its available heat.

It is very important that the boiler should be made airtight so that the air for combustion enters the draft-inlet door. Thermostatic control, properly connected to the draft dampers, effects a great saving in fuel and gives a more uniform heat.

It has been demonstrated by actual practice that this method of operation, compared with the average manner of operation, will result in a great saving of fuel.

P. J. DOUGHERTY.[1] At least 5 tons of coal per year are wasted in the average 10-room residence due to excess air leakage through loose fitting jambs, windows and doors. Assuming a clearance of $\frac{1}{16}$ in. around the windows and doors, the total area of such openings is equal to that of a 24-in. pipe. Allowing one-half of this area for air infiltration, at least 40,000 cu. ft. of cold air per hour enters the building, while 9000 cu. ft. per hour is ample for a family of five. In zero weather it requires about 5 lb. of extra coal per hour to heat this large amount of excess air.

The heat loss through an 8½-in. brick wall and plaster is 1.8 times as much as through a 13-in. brick wall furred and plastered; or twice as much as through a 17½-in. brick wall furred and plastered. In frame construction the heat loss through a wall consisting of clapboard, studded and plastered, is 1.4 times that through clapboard, paper, studding and plaster; or 1.9 times that through clapboard, paper, sheathing, studding and plaster. It is quite evident that a judicious use of building paper and interlocking metal weather strips are gilt-edge investments in reducing coal bills.

The next important leak to be stopped is the excessive escape up the chimney of unconsumed gases such as carbon monoxide, hydrogen, hydrocarbons and carbon. The fuel bed itself acts principally as a gas producer. About one-half of the heat energy of the fuel passes into the combustion space in the form of combustible gases. Unless the combustion conditions within the heater are right, these unconsumed gases carry nearly half the heat value of the coal up the chimney as a dead loss, irrespective of how low the smoke-pipe temperature may be. A high combustion temperature, not less than 1000 deg. fahr., is absolutely essential to produce economic combustion. Invariably a low combustion temperature accompanies a weak draft.

A weak draft, improper firing or faulty heater design are the usual causes of high coal bills because of unfavorable combustion conditions within the heater. The strength of a natural draft depends primarily upon the average temperature of the gases within the chimney, which should range from 300 deg. to 500 deg. fahr., depending upon the height of the chimney. Because of excessive leakage of cold air into the average chimney, and the maximum chilling effect due to the usual 4-in. chimney walls, it is no uncommon condition to have the flue gases chilled from 800 deg. to 200 deg. fahr. in passing from the bottom to the top of the chimney. This condition gives an average stack temperature of 500 deg. fahr., the requirement for the average low outside chimney 35 ft. or less in height. A properly designed heater will therefore permit the gases to escape to the stack at from 400 to 800 deg. fahr. in order to maintain the required temperature in the chimney.

Leaky chimneys are the bane of a heating engineer's existence. A heater cannot deliver heat to the system unless the draft is strong enough to first generate the heat from the fuel. A weak draft changes a heater from a heat producer to a gas producer. The combustible gases escaping up the chimney unburnt are the same gases that are purchased from the gas companies for cooking and lighting. A large saving in fuel and loss by fire could readily be accomplished if the Board of Underwriters as well as city ordinances and architects should demand a smoke test to prove a chimney tight before accepting it, as is the case in testing all plumbing and electrical installations before acceptance.

A strong draft properly controlled is the best fuel economizer on the market. In the average residence the available draft at the smoke damper should be about 0.2 in. of water. A sensitive draft gage of the Ellison type with a 15 to 1 ratio should be part of the equipment of every heater. No house owner can intelligently regulate the draft without a sensitive draft gage.

A strong draft not only saves coal by producing a high combustion temperature to burn the combustion gases, but it materially increases the effectiveness of the heating surface of the heater. The heating surface of the combustion chamber will absorb 2⅓ times as much heat when the combustion temperature is 1350 deg. fahr. as when at 950 deg., the steam or water against the heating surface being at 212 deg. High combustion temperature is far more important than low stack temperature in burning fuel economically. It is far more economical to permit 20 per cent of the fuel energy to pass into the chimney as high stack temperature in order to produce the necessary draft, than to suffer the loss of 40 per cent of the fuel energy in the form of unconsumed gases due to a low stack temperature.

Excess air passing through the heater is a frequent cause of high coal bills. A thin fire on the grates, 12 in. or less, or a strong draft improperly controlled are the principal causes of heat loss through excess air as indicated by a low percentage of CO_2 (from 5 to 10 per cent) in the flue gases.

A deep bed of fire and ash on the grates at all times, from 16 to 20 in., will materially reduce the heat loss due to excess air. Excess air produces such a chilling and deceiving effect that more actual heat units escape from a heater whose flue gases show a temperature of only 300 deg. fahr. and 5 per cent CO_2, than escape from a heater whose flue gases show a

[1] International Heater Co., Utica, N. Y.

temperature of 800 deg. fahr. and 15 per cent CO_2. The former condition represents 19.6 per cent of the heat of the fuel, while the latter with its high stack temperature and low excess air represents only 18.5 per cent of the heat units passing up the stack as sensible heat.

B. J. DENMAN. The greatest saving in districts using bituminous coal for residence heating is to be obtained by encouraging the use of coke. In most residence heaters, the volatile matter is distilled off without being consumed, due to the general practice of filling up the furnace in endeavoring to cut down the frequency of firing. This can be avoided by advocating frequent and light firing of coal, or by the use of anthracite coal or coke. The use of thermostats for residence heating is very desirable, and would result in a material saving of fuel in the average house.

Most people do not appreciate the saving which can be effected by having a door or heavy curtain at the top of the stairway, so that the upstairs can be cut off. This makes it possible to heat only as much of the upstairs as is necessary, and prevents disagreeable drafts coming down, if the upstairs is not heated. It also prevents the chilling of the entire house, due to bedroom windows being raised during the night. An enormous saving could be effected if every one would cut off as many sleeping rooms as possible.

C. E. VAN BERGEN. Fuel may be saved in residence heating by using the smaller sizes of anthracite coal such as pea and No. 1 buckwheat. These can be used by careful handling of grates, taking care at all times to keep some ashes on or over the grates, to prevent the small coal falling through grates.

Do not shake or dump the grates roughly and if coal begins to run through grates, stop it by pushing down enough coal with poker to plug the hole.

WALTER E. BRYAN. Waste in residence heating is due, to a great extent, to ignorance of proper methods of handling heating apparatus. I have found that when it is not necessary to push the fire hard, the most economical results are obtained by keeping the ashpit door and firing door (including the slide) tightly closed and opening the damper in the smokepipe, which allows air from the outside to enter. The keeping of the fire door tightly closed may result in a little smoking immediately after firing, but it also results in a more even temperature and prevents cold air from being drawn in over the fire.

10 What Coal Economies Can Be Effected in the Small Steam Plants?

Plants which are not sufficiently important departments of their industries to warrant expert supervision and are too small to support real engineers waste a lot of coal and steam in the aggregate. What are the principal sources and methods of waste and how can they be avoided and corrected?

E. H. KEARNEY.[1] We would be lacking in the gift of foresight if we allowed ourselves to be lulled into the belief that at the present time, by virtue of existing conditions, a form of fuel conservation hysteria were sweeping over the country and that at the termination of a few months or a few years a return would be had to normal conditions—and to normal conditions is meant a relapse to pre-war price, production and consumption. In all probability, not in our day and generation will we again see the time when the commodities which enter into power-plant operation can be secured with the same facility which obtained previous to the present tightening-up-all-round period.

This is a thought which should occupy our minds to the exclusion of lesser things in dealing with present and future power plant conditions—we as engineers are the nation's fuel conservators.

In order to bring about the best possible efficiency in the plant, the operating engineer should, figuratively speaking, "camp" in the boiler room. Not a single detail of its operating conditions should escape his personal attention—methods of firing, condition of fires, leaks in settings, adjustment of draft, temperature of feed water and condition of feed pumps are but a few of the many things which should engross his attention. In short, the engineer does well who keeps constantly in mind the truth of the old adage, "If you want a good job done, take pains to do it yourself."

For several years preceding the war period there was a growing tendency upon the part of owners and engineers of medium-sized plants to install apparatus in the boiler room by which a closer check could be had upon fuel consumed, water evaporated, quality and temperature of gases, etc. Larger plants were equipped with these aids to economy as a matter of course, and the beneficial results which attended the operation of these more modern systems had set a worthy example for less pretentious plants to follow.

If increasing scarcity and cost of fuel had been the only factors to be dealt with, it is easily seen that firms dealing in scientific power-plant apparatus would have been swamped with orders. Had prices and delivery remained a fixed quantity, there would have been a scramble on the part of engineers of smaller plants to obtain apparatus which during the 24-hour period would enact the part of watch dogs of the coal pile. But while war conditions brought about a scarcity and soaring price of fuel, they also affected the apparatus manufacturer in like degree with the result that the modest plant owner found himself between two fires; either to install checking apparatus at a tremendously increased cost, provided he could secure it at all, or to continue under the old order of things by obtaining the best results possible with what he had in hand. Right here is presented a problem for the plant owner who is interested not only in the matter of his own fuel costs, but in the larger scheme of national fuel saving as well.

There is no question but that many plants which are now being operated without adequate provision for bookkeeping and cost checking could make a decided improvement in the appearance of the monthly balance sheet without the expenditure of extravagant sums. It should be the ambition of every power-plant owner and engineer to ascertain beyond reasonable doubt, through the medium of practical expert advice if necessary, whether or not his plant is being operated under conditions which square with good practice.

Reduced to its lowest terms the whole fuel problem as far as we engineers are concerned is just this: *Voluntary* fuel saving there *should be;* if not, *compulsory* conservation there *must be.* We as engineers must accept as a duty our share in the great task which now confronts the nation.

[1] Supt. of Bldgs., John Hancock Mut. Life Ins. Co., Boston, Mass.

D. C. FABER.[1] The possibility of improvement in boiler-room equipment and firing methods in small steam plants was very forcibly impressed upon engineers connected with the fuel-conservation work done in Iowa under the direction of the Fuel Administration last winter. In connection with this work, combustion conditions were investigated in about one thousand small steam plants, for the purpose of determining what could be done to improve boiler-room efficiency. While it is not possible to enumerate here the conditions found, there are a number of faults which are common to most plants of this type. In many of these plants the firemen have other duties which take them away from the boiler room for a great part of the time, so that firing instead of being a principal duty becomes merely an incidental one. Under such conditions the firemen usually do about all that is expected of them, which is to shovel enough coal from the pile into the furnace to keep up steam, regardless of how or when this is done, so that carrying too thick a fire, firing too large quantities at one time, and failure to regulate fire with damper in uptake are common faults. Air leaks in boiler settings, bare steam pipes and failure to remove soot and scale at frequent intervals account for a large percentage of the fuel losses in such plants.

Many of these faults can be done away with only through education of owners and operators. Right now, on account of the general interest in fuel economy, is the time to start such educational work. Supervision under direction of the Fuel Administration could well be a part of such educational work. Results can be secured now in the small steam plants which would be impossible under other circumstances.

GEO. H. DIMAN. One of the best ways to save coal is to save the heat units. This can be done in many ways. First, be careful not to have the rooms in the manufacturing plants overheated. Do not allow steam on in rooms with windows open. This summer, see that all the window frames are properly pointed so as to admit no cold air. If operating dye-houses, utilize all the available heat units in the dyehouse and finishing departments.

Let me illustrate what I mean. In one of our large mills, some years ago, the dyeing and finishing departments got behind with their work. In order to get the goods into the market we stopped the mill, running nothing but the dyeing and finishing departments. When the mill was running full we used about 6000 hp. and burned 1000 tons of coal per week. This power was generated by two pairs of cross-compound engines, sacrificing on the vacuum, and keeping the discharge water in the condensers at 110 deg. All this water was stored in the finishing department in tanks for washing the goods. A simple engine of 2400 hp. furnished exhaust steam for use in dyeing.

When we ran two weeks with only the dyehouse and finishing room we used direct steam, and ran only one engine. It took 275 hp. to turn the shafting of the dyehouse, and we burned 775 tons of coal per week.

It will be seen that in the first case, where the heat units were utilized as far as possible, we got 6000 hp.; while in the other case, where direct steam was used, we got only 275 hp. and burned three-quarters as much coal as before.

B. J. DENMAN. It is our belief that even in large plants, insufficient attention is paid to intelligent operation of the various boiler and engine units. Efficiency curves of boilers, engines and turbines should be made, and the units operated at their most efficient point. Great savings are possible in many plants if this is done.

One point frequently overlooked is the temperature of the hotwell in condensing units. The amount of circulating water pumped should be varied with the temperature of the circulating water, and the temperature of the hotwell kept as near that corresponding to the vacuum as possible, to reduce the heat loss to the circulating water.

A. G. CHRISTIE. This question was discussed informally at one of the meetings of the Baltimore Section last winter. It was pointed out that inefficiency in small plants was generally due to the following causes:

a Practically all horizontal return tubular boilers in the Baltimore district have been set too close to the grates owing to the fact that a local concern cast boiler fronts from a pattern which allowed only about 20 in. between boiler and grate surface. This had been increased in several cases to 6 ft. with decidedly satisfactory results.

b Air infiltration through cracks in the setting.

c Failure to keep the heating surfaces clean.

d Improper firing methods.

It was pointed out that economies could be secured by:

a Offering a bonus for coal saved.

b Keeping careful records of coal used and posting these.

c Providing a sufficiently large combustion space over the grates.

d Insisting on clean tubes.

e Using prepared mixtures to make the setting airtight. Several are on the market. The settings must be inspected periodically to see that they are kept tight.

f Elimination of steam leaks through joints, faulty traps, etc.

CARL J. FLETCHER. The question as to coal economies that can be effected in small steam plants in the aggregate is one of the most important questions asked. The fuel cost in these plants is too small to permit the proper expert supervision and the possibility of saving much greater than in the larger plants. After an examination of a great many small plants, I have two suggestions to offer which would result in a very great saving:

Most plants clean the inside of their boilers fairly well; but it is my observation that when soot is removed by hand blowing (done at night when the pressure is low), it is one of the most neglected jobs around the boiler room. Automatic soot blowers should be installed and should be used several times a day.

One other possible saving is in the use of the damper on the individual boilers. Plenty of advice has been given regarding this feature, but I find in most plants that the dampers are inconveniently placed, and often not in real operating condition. As the first step, the plant management should insist that dampers are in good condition, equipped with levers which are within easy reach of the firemen. The damper should be easily controlled by means of a proper handle, placed where the fireman would not have to walk behind boilers to reach it.

P. W. THOMAS. Economies approaching 50 per cent of the requirements in small steam plants of, say, 200 to 500 hp. can often be effected by simply putting the plants in shape. We have a record of one plant using 22 tons daily which now uses 11 tons, and the owners bought no fuel-saving equipment

[1] Consulting Engineer, U. S. Fuel Administration, Des Moines, Iowa.

except firebrick, baffle brick, asbestos and fireclay. The 11 tons were saved by the proper education of the men in the boiler room.

WALTER E. BRYAN. Probably the greatest loss in such plants is due to dirty boilers, improper firing and handling of dampers. If this fact, together with the remedy, could be placed in the hands of the managers of industries who are operating small plants, considerable saving would result.

C. E. VAN BERGEN. As long as the war lasts, no plant using coal for generating steam or for heating purposes can be considered too small to require the careful attention of some one within the organization. Fuel must be saved, no matter how small the quantity, and this is just the point which must be emphasized: "Every plant must save some coal." And along with this is another thought that, unless each one of us saves, we may experience a worse coal shortage next winter. And each of us should preach coal saving on all occasions.

11 What Experiences Have You Had with the Storage of Coal?

H. H. STOEK.[1] It is practicable, advisable and advantageous to store bituminous coal not only during war times, but also under normal conditions either at the mines, near the point where it is to be used; or at some intermediate point. It is well to store coal as near the point of consumption as possible to avoid rehandling and for the following reasons:

a To insure the fuel consumer of a supply of coal at all times
b To take advantage of lower freight rates, or of lower prices of the coal at certain seasons of the year
c To permit the railroads to utilize their cars and equipment to the best advantage
d To permit the mines to be operated more steadily.

KINDS AND SIZES OF COAL THAT CAN BE STORED

Although it is undoubtedly true that some coals may be stored with greater safety than others, the danger from spontaneous combustion is due more to improper piling of coal than it is to the kind of coal stored.

Most varieties of bituminous coal can be stored in the air if of proper size and if free from fine coal and dust. The coal must be so handled that dust and small coal are not produced in excessive amounts during the storing, because spontaneous combustion is due mainly to the oxidation of the coal surface.

All varieties of bituminous coal can be stored under water, which excludes the air and prevents spontaneous combustion.

The danger of spontaneous combustion in storing the coal is very greatly reduced if not entirely eliminated by storing only lump coal from which the dust and fine coal have been removed. Of two coals the least friable should be chosen for storage purposes, because less dust and fine coal will be produced in its handling.

Fine coal or slack has sometimes been successfully stored:

a By preventing air currents through the pile by means of a closely sealed wall built around the pile
b By closely packing the fine coal. Such a coal pile must be closely watched for heating. Piles of slack must be very closely watched for heating and means provided for promptly moving the pile if heating develops. The only absolutely safe way to store slack or fine coal is under water
c Many varieties of mine-run coal can not be stored safely because of fine coal and dust mixed with the lumps
d Coal exposed to the air for some time may become "seasoned" and thus may be less liable to spontaneous combustion, due to the oxidation of the surface of the lumps of coal, but opinions are by no means unanimous upon this point
e It is believed by many that damp coal stored on a damp base is peculiarly liable to spontaneous combustion, but the evidence on this point is by no means conclusive. It is safer not to dampen coal as or after it is placed in storage.

[1] Professor of Mining Engineering, University of Illinois, Urbana, Ill., Chairman of Fuel Conservation Committee, Fuel Administration of Illinois.

EFFECT OF SULPHUR ON SPONTANEOUS COMBUSTION

It has been shown by experimentation that the sulphur contained in coal in the form of pyrites is not the chief source of spontaneous combustion, as was formerly supposed, but the oxidation of the sulphur in the coal may assist in breaking up the lumps of coal and thus increase the amount of fine coal, which is particularly liable to rapid oxidation. Even this latter opinion is not unanimously endorsed. In spite of experimental data showing that sulphur is not the determining element in spontaneous combustion, the opinion is very widespread that, if possible, it is well to choose a coal with low sulphur content for storage purposes.

METHOD OF PILING COAL

To prevent spontaneous combustion, coal should be so piled that air can circulate through it freely and thus carry off the heat due to oxidation of the carbon, or else it should be so closely piled that air cannot enter the pile and oxidize the fine coal.

Stratification or segregation of fine and lump coal should be avoided since an open stratum or a chimney of coarse lumps of coal gives a passage for air to enter and come in contact with fine coal and thus to oxidize it and start combustion.

If space permits, low piles are preferable, as the coal is thus more exposed to the air and better cooled than in high piles, and in case of heating it can be more readily and quickly moved. A disadvantage in high piles is the greater difficulty of moving the coal quickly, if necessary. The idea that a high pile causes heating at the bottom is erroneous, since as many fires take place near the top as near the bottom and near the outside as near the interior of the pile. If possible, the coal pile should be divided by alleyways so as to facilitate rapid loading out of the coal in case of necessity, so that an entire coal pile may not be endangered by a local fire.

Much of the attempted ventilation of coal piles in the United States has been inadequately done by the use of only an occasional ventilation pipe which has been not much more than a place in which to insert a thermometer for reading temperatures. The practice of placing ventilating pipes close together has been used in Canada and is reported to have been effective.

Water is an effective agent in quenching fire in a coal pile if it can be applied in sufficient quantities, but a small amount is ineffective. Unless there is an ample supply of water to thoroughly quench the fire and cool the pile, it is very dangerous to add any water to a coal pile.

Coal of different varieties should not be mixed in storage if this can be helped, for one coal that has a greater susceptibility to spontaneous combustion than the other may jeopardize the safety of other coals that are not so liable to spontaneous combustion.

Effect of Storage on Value of Coal

The heating value of a coal as expressed in B.t.u. is decreased very little by storage, but the opinion is very widespread that storage coal burns less freely when fired in a furnace. Experiments indicate that much of this can be overcome by keeping a thinner bed on the grate than is kept with fresh coal and by regulating the draft.

The coking properties of most coals seem to be decreased as a result of storage.

The value of coal for making illuminating gas is not decreased as a result of storage.

The deterioration of coal stored under water is negligible, and such coal absorbs very little extra moisture. If only part of a coal pile is submerged, the part exposed to the air is still liable to spontaneous combustion.

Additional Precautions

The best preventive of loss in coal storage is to inspect the pile regularly and if heating occurs up to 150 deg. fahr. to keep very close watch on the pile; and if the heating increases to 175 or 180 deg., to remove the coal as promptly as possible from the spot affected, and thoroughly cool it before piling it again.

Storage appliances and arrangements should be so designed as to make it possible to load out the coal quickly if necessary, and the coal should not be stored in large piles unless provision is made for loading it out quickly.

Pieces of wood, greasy waste, or other easily combustible material mixed in a coal pile may form a starting point for a fire, and every effort should be made to keep such material from the coal as it is being put in storage.

It is very important that coal in storage should be kept from such external sources of heating as steam pipes, because the susceptibility of coal to spontaneous combustion increases rapidly with an increase in temperature.

T. N. Wynne.[1] The Indianapolis Light and Heat Company has been storing Indiana coal since 1888. Before 1912 all coal stored was on the ground in open air, with no particular attention paid to sizes, quality, or the method of storing. In 1912 this company investigated the question of storing coal under water to prevent spontaneous combustion and loss of heating value. No. 4 vein Indiana coal contains approximately 2 per cent of sulphur and No. 5 vein from 3½ to 6 per cent, and our experience has been that No. 5 will invariably fire if exposed to the air, while No. 4 will not. While we feel it safe to store No. 4 coal on the ground, it is so difficult to obtain that we feel it necessary to provide storage that will be safe for No. 5. We burn No. 4 on Roney stokers and No. 5 on Green chain grates.

An average of 741 tests shows the freshly mined No. 4 vein coal to contain about 35 per cent of volatile combustible matter. From tests of various samples taken from No. 4 coal stored for three years in open air at our Kentucky Avenue Station the volatile content was found to average 28.34 per cent, indicating a loss of 20 per cent. This coal during its period of storage did not show any signs of heating.

At the same station we have had stored for about eight months 2000 tons of No. 4 vein Indiana mine-run coal. This coal has never shown a tendency to fire, although in places it is 35 ft. deep.

The history of coal storage by our company has been a series of fires and losses. In 1912 we constructed at our Mill Street Station a concrete pit 300 ft. long, 100 ft. wide and 20 ft. deep, designed to contain 13,000 tons of coal submerged. A standard-gage track crosses this pit at ground level from one end to the other on concrete piers. The cars are run upon this track and dumped. After the coal has reached a certain height it must be handled to both sides of the track by means of a Brown hoist. The topography of the ground prevents the elevation of track to facilitate dumping, a condition very desirable if possible. The pit when filled is not disturbed except in case of shortage in daily delivery. Mine-run coal only is stored because screenings under water become a mud-like mass, almost impossible to handle or burn.

Capillary attraction will take care of coal piled above the water level of the pit as much as 8 or 10 ft., thus permitting of additional capacity of about 40 to 50 per cent.

Whenever coal is taken from the pit to be used on the stokers it is loaded into railroad cars and the water allowed to drain off for about six hours before the coal is put into the bunkers; or, when coal is to be taken from the pit the water may be lowered until sufficient coal has been uncovered and drained to meet the requirements.

The result of underwater storage fully met our expectations in that it prevented fires and preserved the heating value of the coal. We have never been troubled with excessive moisture when burning pit coal if mine run is used. Screenings which have been stored under water burn with difficulty.

A loss of heating value is very evident in the case of coal stored in air. In fact, when burning air-stored coal it is necessary to have additional boiler capacity to carry the same load.

Results of 181 tests of No. 4 vein coal which has been submerged for one year as compared with those of the 741 tests of freshly mined coal previously referred to, show a reduction of 1.7 per cent in available B.t.u. in the case of the submerged coal. This loss is so small that it might very well exist between two lots of freshly mined coal.

Recently we constructed a reinforced-concrete coal pit at our Kentucky Avenue Station, 145 ft. long, 65 ft. wide and 32 ft. deep, built on the same general lines as that at the Mill Street Station and holding 8000 tons.

The Indianapolis Light and Heat Company burns 500 tons of coal per day, and as the two pits have a total capacity of 20,000 tons of coal submerged and 10,000 tons above the water line, this means a sixty days' supply on hand if both pits are filled. The total cost of the two pits was $60,000 or $2 per ton of storage.

Albert A. Cary. Another phase of the coal-wasting proposition is that of spontaneous combustion.

With the clean coal formerly received by a certain large power plant, running low in percentage of non-combustible matter, trouble from spontaneous combustion was almost unknown even after the coal had been stored for six or seven years in dense piles.

With the coal now received they find that they cannot store it for two weeks without spontaneous firing; in fact, they have such fires burning in their coal bins almost continuously, with

[1] Indianapolis Light & Heat Co., Indianapolis, Ind.

the result that when this supply is drawn upon for use they have coke to burn instead of coal.

With the valuable heat-producing volatile matter thus distilled out of our eastern bituminous coal, the loss in steam-making capacity is from 10 to 15 per cent.

Should coals from the Central West be used (which coals contain a considerably higher percentage of volatile matter), the amount of such loss is materially increased.

Loss from spontaneous combustion simply means that a correspondingly *greater amount of coal* must be carried over our transportation systems from the mines to make up for the deficiency thus created.

The spontaneous combustion of coal is occasioned by the combination of some of its constituents (including impurities) with atmospheric oxygen, which reactions raise the temperature of the surrounding coal to its ignition point.

Whether this firing is due to the presence of that easily decomposed form of iron pyrites known as marcasite or to the presence of other impurities, it is difficult to say, but we have the strongest evidence—at the large power station referred to —that with the clean coal formerly received, no loss due to spontaneous combustion occurred, but with the dirty coal that is now being received, such firing is almost continuously occurring. Generally speaking, the coals running the highest in non-combustible matter give the greatest trouble due to spontaneous combustion.

As regards the statement that coal containing 40 per cent of refuse is valueless as a fuel, I would say that there is no doubt coal with such a high percentage of refuse will be found to be a very undesirable fuel, but whether it can be burned to produce useful results depends largely upon the rate of combustion, the facilities available to give the fuel bed the requisite air supply, and the skill of the fireman.

It is desirable to know just what is meant by the term "refuse." The word is commonly used to denote the total matter rejected from the furnace, which includes the combustible matter contained in the so-called ash. If it is intended to mean pure ash, or wholly incombustible matter, it is doubtful whether a steam boiler could be operated with such fuel. On the other hand, if it is intended to define the pure ash with accompanying combustible matter, such as is commonly rejected from boiler furnaces, I know that the remaining 60 per cent of fuel has been used successfully for purposes of steam generation.

In the office building in which my office is located they received the so-called steam sizes of anthracite coal last winter and managed to carry their load and maintain the regular steam pressure, burning this coal when taking 42 per cent of refuse out of the ashpit and furnace.

This plant is equipped with five 400-hp. boilers and the ratio of heating to grate surface is 49 to 1. The furnaces are hand-fired, and when burning this dirty coal they maintained a blast pressure of 1¼ in. water pressure under the grates and developed from 70 to 75 per cent of the boilers' rating, as shown by the steam-flow meter.

Much credit is due to the chief engineer of this plant, whose instructions to the firemen made it possible to obtain such remarkable results under adverse conditions.

P. W. THOMAS. Our personal experiences with storage coal may be of great interest. All of our coal is of a nature that heats very quickly. Where we are unable to procure underwater storage, we adopt the following plan:

The storage place is first absolutely cleaned of all rubbish in the way of deadwood and vegetation. We then cover the entire area with coal to the depth of about one foot. After this coal has been exposed to the air for one or two days, we place another layer above it. We continue this to a depth of 8 to 10 ft., being careful to store only coal from one given mine. We have carried raw screenings over a period of a year without smolder, where under ordinary circumstances they would have fired in from one to three weeks. A scientific explanation would be rather difficult, but in all likelihood would center around the undoubted fact that each layer so put down has time to lose the majority of its occluded gases and becomes more or less inert. The pyrite also has time to become partially or wholly oxidized.

I note that in Question No. 1 there is a statement regarding the amount of refuse which renders a fuel valueless. I might make the absolute statement that it is not the amount of refuse, but its character. I have successfully burned fuel running 45 per cent ash, but this ash was inert and absorbed no heat from the coal to exceed 3 or 4 per cent. On the other hand, a fuel containing 31 per cent ash, which ash was 90 per cent metallic, failed to carry boiler ratings, although its heating value was over 10,000 B.t.u. per lb. This was due to the fact that approximately 11 per cent of the initial heat in the coal was absorbed by the ash, whereupon it became impossible to maintain a combustion rate that would give sufficient heat to the boiler.

WALTER E. BRYAN. Where coal is not too small in size and contains few impurities, it can be stored either under roof or in the open for long periods with little danger from combustion and, I believe, little deterioration. We have found it necessary in storing screenings, of rather poor quality, under roof, to allow them to stand not longer than three to four weeks in warm weather. In the open it is almost impossible to store such screenings during the summer months without firing, and with the comparatively poor coal supplied last year it was impossible to store the coal for any great length of time, even in the winter months, without its catching on fire. In my opinion, the question of ventilating storage piles is of questionable value, the important points being not to store too fine coal or dirty coal, and not to store it in large piles.

In case the coal actually does fire, I know of no effective way to put the fire out; it is our practice to pick up the coal as rapidly as possible and use it. I realize, however, that there are several methods of chemically treating the coal after it has fired which are supposed to put the fire out. In the case of coal stored in buildings, care should be taken after emptying a bin that all pockets are brushed out before the new coal is put in.

B. J. DENMAN. Up to a few years ago I was in charge of plants burning Pennsylvania and West Virginia coking coals which required storage of approximately 100,000 tons. Mine-run coal was stored in continuous piles as high as could be handled by locomotive cranes. No attempt was made to ventilate the piles, and no fires ever occurred. There was no loss in heating value of coal which had been in storage as much as three years.

I am at present storing eastern Kentucky "Elkhorn" gas coal for nine gas plants. Most of this is under cover, but some is unprotected. This coal is stored in piles as high as 25 ft., and no precautions are taken, but no fires have resulted. Most of this coal is ¾-in. lump, but some of it is screenings. Some of the lump coal has been in storage for five years or more.

For electric plants, I am at present storing each winter in various localities from 3000 to 20,000 tons of Illinois and Iowa coal. It is our experience that washed central Illinois coal screenings can be put in stock during the summer and used the following winter with very little danger of firing. Springfield, Ill., district 1¼-in. screenings cannot be put in stock in summer without great danger of firing. If this coal is put in stock during the winter time, when the coal is very cold or mixed with snow, it will ordinarily carry through the following summer. Fulton County, Ill., screenings will ordinarily fire before fall if put in stock during the summer months, although we have one plant in northern Iowa where we put about 3000 tons of this coal in stock each year and have very little trouble; in a number of plants in the central part of the state, however, trouble invariably results. This may be due to some climatic condition, but we have not been able to account for it.

We have had very satisfactory results in storing southern Illinois screenings and experience very little trouble. The lump coal from any of the Illinois districts can be carried through the summer without trouble.

Iowa screenings cannot be stored at all during the summer time, and frequently the coal fires in transit. I have had no experience in storing Iowa lump, but am of the opinion that it would disintegrate and fire.

I have had little faith in the usual schemes for ventilating coal piles, and have observed several experiments which have not been satisfactory. It is our practice not to store the coal over 12 ft. high, and if it begins to heat, to move it as quickly as possible.

A. G. Christie. I have found it impossible to store certain grades of western lignite if wet even in as shallow piles as 6 ft. without having spontaneous combustion. Alberta bituminous coal could be stored in piles 12 ft. deep if kept dry. Wet weather may start combustion. We have had no difficulty storing semi-bituminous coal in piles of 12 ft. deep in Baltimore, but care is taken to keep it dry.

Carl Smerling. It is comparatively safe to store bituminous coal containing up to 1½ per cent sulphur in piles not exceeding a depth of 7 to 8 ft. and not be troubled with spontaneous combustion. The same kind of coal can be stored at any depth if supplied with sufficient air pipes penetrating the storage at proper intervals, although we find that in 50 per cent of the cases where bituminous coal is stored, especially through the Middle West, hundreds of tons of coal are lying in the open for years 20 to 30 ft. in depth and containing from 2 to 2½ per cent sulphur. It must be noted, nevertheless, that in all cases spontaneous-combustion fires are found at the bottom of the pile or at the floor level, and it therefore seems advantageous to have from a foot to eighteen inches of water at the bottom of the pile to insure safety.

C. E. Van Bergen. We do not recall any interesting experiences in connection with coal storage, having never had any large quantities to deal with, nor have we had any fires in storage piles. We do not store until fall, and about 1000 tons well spread in piles not over 15 ft. high is the most we ever have on hand.

W. L. Abbott. We have stored hundreds of thousands of tons of bituminous coal every year at a cost not to exceed 10 cents per ton into and out of storage. We have had no trouble whatever in many years with spontaneous combustion in the coal piles. It has been our experience that we can prevent spontaneous combustion by storing grades of coal that do not contain the small sizes, using preferably a 3-in. by 6-in. egg or lump size of coal which has gone over a 1½-in. screen.

12 (a) To What Extent and Where Will the Gas Producer Be Used to Produce Economies?

Robert H. Fernald.[1] There seem to be three obvious fields for producer gas development:

1 For extensive power production at the mines
2 As a substitute for natural gas for general heating purposes
3 In conjunction with by-product coke ovens.

1 In the field of power production through the internal-combustion engine the application of the gas producer seems limited to plants of relatively small capacity. This is due to the fact that the practical size limit for gas engines seems to be not over 5000 hp., and very few engines of this size are built. The gas-engine-gas-producer combination can hardly be considered for central station service. For large power installations the natural development is the by-product producer-gas plant located at the mines in conjunction with steam boilers and steam turbines. The low efficiencies due to the two-step conversion—first, gas generation from the coal and, second, burning of the gas under steam boilers—may be counterbalanced by the development of highly efficient boilers equipped for gas burning, and by the return from the valuable by-products secured from the coal. Should the development of the gas turbine result in commercial units that compare favorably with the present large steam turbine units, additional marked economies may of course be looked for.

2 The depletion of the supply of natural gas in many regions is leading to the gradual substitution of producer gas in place of natural gas,—using producers of either the by-product or non-by-product type.

3 This field embraces two divisions; (*a*) one in which there is an unlimited demand for the coke from the ovens as well as for the gas and by-products; (*b*) one in which there is no market for the coke but a ready market for the gas and by-products.

a This type of plant is composed essentially of two distinct installations, a by-product coke plant and a by-product producer gas plant. The entire gas output of the coke plant may thus be made available for the market, as the lower heat value producer gas may be used for heating the coke ovens. One of the advantages of this system lies in the fact that coke breeze and low-grade fuels may be used in the producers. In a large European plant of this type the coke oven gas is the main product and the coke, which finds a ready market, is regarded as one of the by-products. The by-products from the producer-gas plant, sulphate of ammonia and pitch, practically pay the cost of operation of this portion of the installation.

[1] Professor of Dynamical Engineering, University of Pennsylvania, Philadelphia. Mem.Am.Soc.M.E.

b In case there is a demand for the by-product coke oven gas but no convenient market for the coke, the natural step involves placing gas producers in close contact with the by-product coke plant, feeding the coke directly into these producers. Such portion of the producer gas as is not used for heating the coke can be mixed with the by-product coke oven gas for general distribution.

Developments along the three lines indicated seem to offer attractive possibilities, and their adoption on an extensive scale would lead to economy in fuel consumption.

12 (b) To What Extent Is Natural Gas Being Used as a Fuel for Power Purposes?

Samuel S. Wyer.[1] The natural gas industry is in a transition stage, changing from the large-volume, low-price-per-unit basis, to the relatively small-volume and larger-price-per-unit basis. The reasons why natural gas cannot and ought not to have an extensive use for steam-boiler work in the future may be enumerated as follows:

a The number of domestic consumers, now over 2,363,000, is increasing much faster than the number of producing wells

b The initial production and the routine available production coming in are much lower than for wells that came in five years ago. This is due to the general depletion of existing fields, and the extensive underground drainage from past production

c New fields are not being discovered fast enough to replace the rapidly declining present supplies

d The general shortage of coal for domestic heating in the past and the inevitable continuance of this condition for some time in the future, at least during the period of the war, has placed enormous additional demands for domestic heating on the natural-gas resources where natural gas is now and will be used in lieu of solid fuels for heating homes.

Natural gas is preëminently a domestic fuel. Its high heating value, practically twice that of any manufactured gas available, its purity, and ease in handling make it the premier fuel for home use. While low-grade solid fuels can be efficiently used under steam boilers with proper stoking equipment, they cannot be satisfactorily or efficiently used for house heating. For this reason it is a matter of conservation to use the fuel for domestic service that in the long run will yield the greatest good to the greatest number.

The tests recently made in the Home Economics Department of the Ohio State University on cooking various meals with natural gas, soft coal, coal oil, gasoline and electricity, show conclusively that natural gas is by far the cheapest fuel for the domestic consumer's use for cooking. Thus, in cooking a dinner for six people, the total fuel costs, with natural gas at 40 cents per 1000 cu. ft., soft coal at $6.50 per ton, coal oil at 15 cents per gallon, gasoline at 27 cents per gallon, and electricity at 3 cents per kw-hr., were substantially as follows:

Natural gas......	0.88 cents	Electricity	5.0 cents
Soft coal..........	2.5 cents	Coal oil	5.4 cents
Gasoline	4.6 cents		

The rendering of domestic natural-gas service is a public-utility business. Practically all of the states where natural gas is now produced and sold have public-utility commissions with broad powers in matters of rate regulation and quality of service. The general tendency, and the one that is in accordance with sound public policy, is to give the domestic consumer first preference and curtail the consumption of natural gas for industrial purposes. For the reasons given in the preceding paragraphs, it may be reasonably expected that this tendency will become more marked in the future and public-utility regulations regarding the use of this best of all of nature's fuels for domestic service will become more exacting and ultimately will result in the very great curtailment of the use of natural gas for steam-boiler work and for other industrial purposes.

12 (c) What Is the Relative Economy of the Locomotive of 1900 and Today?

John E. Muhlfeld. The general development of the steam locomotives in use in the United States since 1900 can be best shown by the data in Table 11, which are approximately correct.

Summary of Economic Features

Prior to 1900 considerable development work had been done on two-, three- and four-cylinder types of compound locomotives by Mallet, Webb, Pitkin, Mellin, Vauclain and others. Pitkin's two-cylinder system was applied to a Michigan Central 10-wheel locomotive in 1889, and Vauclain's four-cylinder system was first introduced on a Baltimore and Ohio 8-wheel locomotive—No. 848—in October of the same year. These and other developments caused the adoption of both the two- and four-cylinder systems in new locomotives, the maximum application being reached during 1904, when approximately 1,000 two-cylinder, and 2,000 four-cylinder compound locomotives were in existence.

Previous to 1900 Schmidt, Pielock and others had done considerable experimenting with superheated steam, the former having succeeded in 1894 in producing a boiler and motor in which superheated steam of relatively low pressure was used at about 700 deg. fahr.

The failure of the compound locomotive to produce the economy predicted—due largely to the factors of indifferent design, lack of proper maintenance and operation, cheap fuel and road failures—resulted in the general return to the single-expansion cylinder locomotive, and this, with the demand for greater steaming capacity per sq. ft. of boiler heating surface, naturally brought about consideration of the use of superheated steam. The results of further experiments by Vauclain,

[1] Consulting Engineer, Columbus, O. Mem.Am.Soc.M.E.

Vaughn, Horsey, Cole, Emerson, Jacobs and others, along the lines of high and low degrees of superheat, in combination with either high or low steam pressures, by means of smoke-box, fire tube, or a combination of both types of superheaters, resulted in the fire-tube type being now practically a standard part of all new equipment, and it is further being rapidly applied to existing saturated-steam locomotives in the United States.

TABLE 11 STEAM LOCOMOTIVES IN THE UNITED STATES SINCE 1900

Year	Item	Single-expansion cylinder	Two-cylinder compound	Four-cylinder compound	Mallet articulated compound	Total locomotives
1900	Number	36,600	1,000	900	..	38,500
	Average tractive power, lb.	19,000	28,000	29,000	..	..
	Average wt. on drivers, lb.	85,000	125,000	130,000	..	..
1905	Number[1]	48,949	900	1,800	1	51,650
	Average tractive power, lb.	23,000	31,000	32,000	75,000	..
	Average wt. on drivers, lb.	100,000	140,000	145,000	335,000	..
1910	Number[2]	56,425	875	1,500	200	59,000
	Average tractive power, lb.	27,000	31,500	40,000	72,000	..
	Average wt. on drivers, lb.	120,000	142,000	175,000	320,000	..
1915	Number[3]	62,000	650	1,300	800	64,750
	Average tractive power, lb.	30,500	32,000	33,000	79,000	..
	Average wt. on drivers, lb.	135,000	145,000	148,000	350,000	..

[1] Includes 1 superheater locomotive.
[2] Includes 300 superheater and 3000 oil-burning locomotives.
[3] Includes 14,000 superheater and 4250 oil-burning locomotives.

While the Cole and Vauclain balanced compound types of locomotives as brought out since 1900—along the lines of the French De Glehn system—have not made much progress, the Mallet Articulated Compound system, introduced on the Baltimore and Ohio in 1904, is now in use on over fifty railways in the United States, and aggregates more than 1,500 locomotives. This latter type of locomotive not only permits extreme concentration of great power over a flexible wheel base within axle-load limits, but also reduces the stresses by greater distribution and lightness of parts, and through the combination of high-pressure superheating, compounding, simpling and reduction of unbalanced pressure gives the maximum direct and reserve tractive power for from 25 to 35 per cent less fuel and water consumption per ton-mile than a superheated single-expansion locomotive.

Comparison of Steam and Electric Equipment for Railways

With regard to the present status of the relative economy of steam and electric locomotives in the United States, as compared with the results obtained in 1900, general conditions have very substantially changed and the predominating factors today are manual labor and fuel for operation. While the inauguration of the use of fuel oil on almost 4500 steam locomotives has somewhat improved the firing and steam-generation conditions, the increasing cost and demand for oil for more essential purposes and the reducing supply will soon make its use for locomotive fuel prohibitive. However, the use of oil as a locomotive fuel has long since demonstrated that the mechanical feeding and burning of fuel in suspension, whether gaseous, liquid or solid, for the production of steam in a self-contained motive-power unit, is the most logical, successful, effective and economical method for generating power and moving long-haul heavy-tonnage traffic on railways.

Even where hydroelectric power is available the self-contained steam-power-plant locomotive will show a much lower cost for fixed charge, maintenance and operation than the electric unit, as the transmission and conversion of electric current into drawbar hauling capacity is a very wasteful and expensive process in the present state of the electrical art. In fact, the principal economies brought about in the electrical field during the past quarter century have been in the production and use of steam for the generation of current and not in the electrical apparatus.

As applied to a long-haul railway, the metering and conveying of extremely high-voltage current from various power-plant sources into transmission mains, through switching substations, transforming and converting, conveying to contact lines and converting into great hauling capacity at the drawbar results in enormous line and bonding dead losses, which will bring the cost of even hydroelectric current per drawbar horsepower hour to from 6 to 7 mills. This cost, which, in combination with copper limitations, fixed train speeds up and down grades, general tie-up of operation in case of failure, and like factors, will hardly admit of comparison with steam-locomotive boilers operating at equivalent to 700 per cent of the rated capacity of stationary boilers, with a 75 per cent combined furnace, boiler and superheater efficiency, and furnishing a boiler horsepower for each $1\frac{1}{2}$ sq. ft. of evaporating surface and producing a drawbar horsepower-hour for $2\frac{1}{4}$ lb. of coal.

Improvements to be Expected in Steam Locomotives

Nevertheless, the steam locomotive is still in its infancy so far as economy per ton-mile is concerned. The atomization and burning of liquid or solid fuels in suspension will enable the elimination of grates and other metal work from the combustion zone and permit of higher furnace temperatures and more complete and effective combustion, which, in combination with higher steam pressures; compounding; higher superheating of both high- and low-pressure steam; utilization of waste gases and steam for feedwater heating and purification; better boiler-water circulation; reduced cylinder clearances and back pressure; improved steam distribution; lower factor of adhesion; higher percentage of propelling to total weight; less radiation; elimination of unbalanced pressures and weights; application of safety and labor-saving devices, and the greater refinement and perfection of general and detailed design, equipment and control throughout, will yet enable it to produce a drawbar horsepower-hour for one pound of coal.

Steam-Electric Locomotives

Furthermore, it is not inconsistent to now predict that a self-contained steam-electric articulated compound locomotive, combining the advantages of both steam and electric motive power, will shortly find a useful field in services where maximum power and efficiency at high speeds; greater utilization of existing waste heat; high starting and low speed torque and rapid acceleration are required and where an exclusive electrification system would not be permissible from the standpoint of first cost or justified on account of the combined expense for operation and maintenance.

12 (d) What Is the Proportion of Coke Made in By-Product Ovens in the United States?

C. E. LESHER.[1] The proportion of coke (excluding gas-house coke), made in by-product ovens in the United States has increased from 17.1 per cent in 1910 to 40 per cent in 1917. The figures, by years, are as follows:

Year	1910	1911	1912	1913	1914	1915	1916	1917
Per cent	17.1	22.1	25.3	27.5	32.5	33.8	35.0	40.0 (Est.)

The development of the by-product coke industry in the United States up to the close of 1914 was largely the result of the recognition by iron and steel companies of the economies possible by the recovery of by-products and of the flexibility of operation, as well as the assurance of a regular and continual supply of suitable blast-furnace fuel.

Beginning in 1915, and most strikingly so today, the necessity for benzol and toluol for explosives and chemical manufacture has given this industry marked impetus. So urgent are the demands for explosives that the Federal Government is expected to finance the erection of additional by-product ovens this year.

These new by-product plants will continue to be operated after the demand for coke—now abnormal—decreases, with the result that the percentage of by-product coke to the total output in the United States will continue steadily to increase.

W. H. BLAUVELT.[1] Preliminary Government estimates place the total coke production for 1917 at 56,600,000 tons, the largest tonnage in the history of the industry. Of this production, 34,000,000 tons, or 60 per cent, was beehive coke, and 22,600,000 tons, or 40 per cent, was by-product coke.

The by-product plants now under construction in the United States will have a capacity of 13,800,000 tons. Not all of these plants now building will be put in operation this year, but the majority of them will, so it seems safe to prophesy that at some time the latter part of this year the production of by-product coke will pass the beehive production. The total capacity of the by-product ovens in the United States now in operation or under construction will be about 40,600,000 tons per annum. This is more than 5,000,000 tons above the maximum production of the beehive industry in 1916, when all of the conditions were favorable to bringing out the greatest possible production from the beehive plants.

12 (e) What Are New and Important Developments in Methods of Burning Coal?

W. W. JOURDIN.[2] Aside from cost, the advantages of fuel oil in steam-boiler practice over rough-crushed coal are so manifest that a particularly strong inducement exists at this time of increasing power costs to apply the economic test to coal in this form.

The superior thermal efficiency of gaseous fuels is unquestionable, but commercial success in the manufacture of gas for firing under boilers has not been realized. Coal, when ground so fine that 95 per cent will pass 100 mesh, can be conveyed through pipes over considerable distances as readily, almost, as oil, and combustion will occur in a manner quite analogous to that of gas, provided air be supplied in proper proportion and in intimate contact with the particles of the coal.

That desirable characteristic of oil—easy and complete control of the heating medium to meet variations in steam demand—is inherent to coal in this finely divided state. Better economy is attainable than with coal as commonly fired, since excess air may be kept within narrow limits, and, furthermore, the boiler room is free from heavy storage and handling equipment.

This feature of quick response to variable load conditions cannot be fully appreciated by one whose experience has been confined to stoker equipment. In the plant with which the writer is connected, the excess air is usually maintained within 10 or 12 per cent of theoretical requirements, and with a 50 per cent variation either way from normal load the automatic regulating system will respond so quickly that the extreme variation in steam pressure will be not more than 2 lb. per sq. in., equivalent to 1 per cent of normal. When properly adjusted the damper regulator opens the dampers in time to prevent smoking, in the case of an increase in the rate of firing, or a "clear stack" with a sharp reduction of load.

Steam is the best atomizing agent for oil, but compressed air appears to be most satisfactory for use with powdered coal. All air required for combustion may be compressed by turbo-blowers to a comparatively low pressure, heated by the waste gases, then released in a mixing chamber or burner designed to distribute the charge evenly in the furnace.

The methods used to atomize pulverized coal fall short of requirements since the evaporative efficiency is generally lower, often up to 10 per cent, than obtained with gas or oil. With well-designed apparatus, however, nearly constant oxygen-carbon ratio should obtain over a wide range, and evaporative efficiency need not be less than is developed in the best oil-burning practice.

The grinding and drying equipment should be placed between the boiler plant and coal in storage. The quantity of waste gases to be diverted to the drying plant will depend upon their temperature and the moisture content of the coal. The best performance known to the writer is 4 to 5 lb. of water evaporated per pound of coal used in the dryer; in certain plants the ratio is nearer unity. Therefore, with coals running high in moisture a material saving will be possible by the use of waste gases in the dryer.

A large pulverized-coal plant is being installed in Seattle, where oil is cheap compared to places more remote from the oil fields. If we cannot afford to burn oil, let us weigh carefully the possibility of utilizing this fine substitute.

[1] U. S. Geological Survey, Washington. Published by permission of the Director.

[2] Chief Engineer, Power Plant, Inspiration Consolidated Copper Co., Miami, Ariz. Mem.Am.Soc.M.E.

[1] Consulting Engineer, Semet-Solvay Company, Syracuse, N. Y.

12 (f) What Economies Have Resulted from Recent Practice in Making Brick Settings Leakless?

Albert A. Cary. The remarkably low flue-gas temperatures frequently reported from boiler tests are generally due to air leakage through boiler settings or at flue connections. A number of boiler tests which I have made were conducted in such a manner as to determine these losses and I will therefore give the results of three or four of these tests from which can be appreciated the gain in efficiency that would result if the air leakage were suppressed.

1 Two horizontal tubular boilers of the same size and located in the same plant, with settings supposed to be identical, gave the following results by taking samples of gas simultaneously from the rear end of the furnace chamber and just inside the flue outlet:

	Boiler *A*	Boiler *B*
Excess of air found in the furnace..	70 per cent	49 per cent
Excess of air found at the flue outlet.	103 per cent	71 per cent

These results clearly show how worthless the gas analysis taken at the flue outlet really is, as an indication of the conditions of combustion in the furnace.

Turning now to temperature readings taken just inside of the flue outlet, a nitrogen-filled thermometer, with proper corrections applied, showed that the temperatures of gases escaping from the boiler settings were as follows:

Boiler *A*	Boiler *B*
543 deg. fahr.	482 deg. fahr.

By making corrections for the chilling effect of the infiltrating air, we find that had there been no air leakage through the boiler settings, the temperature of these escaping gases would have shown, with Boiler *A*, 607 deg. fahr., and with Boiler *B*, 562 deg. fahr.

The actual loss in efficiency due to air leakage in these two boilers was as follows: Boiler *A*, 1.73 per cent; Boiler *B*, 2.13 per cent.

The losses occurring in these cases principally were due to the chilling effect of the cold entering air alone, as it was found that practically all of the air leakage occurred beyond the furnace and combustion chambers. A correction of the gas analysis taken at the flue outlet, making allowance for the increased air supply, shows practically the same results as were obtained in the samples of gas taken from the combustion chamber.

2 I will next refer to two interesting tests made with a water-tube boiler having its heating surface widely distributed, and requiring a setting about double the size of a normal setting. It was equipped with stationary grates and hand-fired. One test was conducted at the rated capacity of the boiler, while the second was a forcing test.

During the non-forcing test, I found that the average excess air in the *furnace* was 45.05 per cent, while the excess air found in the escaping gases, just inside of the flue outlet, was 95.79 per cent. There was an unusually high loss in the combined efficiency of the boiler and furnace operation due to air leakage through the masonry; namely, 4.63 per cent.

The average combustion, during this test, was 20.87 lb. of dry coal per sq. ft. of grate.

During a subsequent forcing test, when 40.15 lb. of dry coal was burned per sq. ft. of grate under forced blast, the entire chamber enclosing the boiler was under pressure so that the furnace gases actually blew out through cracks in the masonry and thus we had a case of gas leakage outward.

There is no necessity for employing extraordinary means to obtain tight boiler settings. Long experience has taught me that the material we have been employing for years, if properly selected and properly erected in place, will produce a setting that for all practical purposes is tight and can easily be made to remain tight for years.

It is the duty of every engineer who is called upon to install boiler settings to study the stresses and strains that occur in boiler masonry the same as he is supposed to do in other designing work and he must also study the widely varying qualities of the various materials used so as to make and secure a proper selection. Extreme expansion and contraction are constantly occurring in nearly every part of a boiler setting and they must be properly provided for. The interior of a furnace wall may be subjected to a temperature of 2000 deg. and running upwards to nearly 3000 deg. fahr., while its exterior is sometimes subjected to a freezing temperature.

What can we expect but disintegration, cracking or distortion, if provision is not made to meet these conditions? With bridge walls or arches heated to very high temperatures and expanding against the side walls, how can we expect such walls to withstand such pressures without cracking unless provision is made to relieve or prevent such thrusts by proper arrangement of supporting beams, buck stays, pockets in masonry, or other means properly applied?

The average mason knows little or nothing about laying up firebrick work and bonding it properly into the red-brick exterior, and yet this most important matter is often left to such men. I always make it a practice to specify exactly how this work should be done.

The market is filled with most undesirable material for boiler setting and if proper refractory material, red brick, mortar, fireclay or high temperature cement is not distinctly specified, the poor client simply buys his trouble and adds to his maintenance account, when he has such unsuitable material dumped into his boiler setting.

Proper provisions must be made for relining furnace interiors without damaging other parts of the setting. Provision must be made for supporting the boiler securely and for taking care of the expansion and contraction of the boiler itself and the greatest care must be exercised to provide ample foundations which will not settle.

12 (h) Is Automatic Air Supply Correctly Proportioned to Coal Supply Possible?

M. C. M. Hatch. Theoretically, such control of the supply of air necessary for combustion would seem to be desirable. There is a certain amount of excess air which, for a given furnace design, method of firing and nature of fuel, will give

the best results, and this excess, expressed as *percentage,* will be constant throughout the entire range of fuel rates, from lowest to highest.

Accurate control of the air for any method of burning coal on grates, either by hand or by stoker firing, is more or less difficult and may be, and probably is, impossible under many conditions. The comparative sluggishness of furnace action with coal thus fired to respond to rapid variation in load on the boiler and the fact that grates will clinker or ash over, changing the air-inlet area under the fire, account in large measure for the difficulties encountered, and these faults would seem to be inherent in grate firing.

Coal burned in pulverized form offers a chance for development work along the line of positive air control. There is no change of air-inlet area to the furnace caused, automatically, by slagging or ash deposits. The excess air necessary can be readily determined and is materially less, on account of intimate mixture, than in other methods of burning coal, hence, for a given fuel rate, the total amount of air to be controlled is reduced. The flexibility of the furnace, by which is meant its ability to respond almost instantaneously to varying demands upon the boiler, is very pronounced, and this again simplifies the problem.

Pulverized coal, fed by carefully-designed screws which give practically constant delivery per unit revolution for all feeds, affords ideal conditions for standardization work in furnace operation. It is entirely possible, although there has as yet been no attempt made to place such an arrangement on a commercial basis, that the position of the main boiler damper and of the dampers in the induced-air pipes may be synchronized with the feed-screw revolutions in such a way as to insure constant air-excess percentage at all furnace outputs.

12 (l) Miscellaneous—School Heating, Insulation, Smoke Prevention

J. H. Brady[1] contributes a report made by him to the Board of Directors of the School District of Kansas City, Mo. This report is given in great detail and is extremely valuable. It contains a tabulated statement for 1916-17, showing the cost per cubic foot for heating the buildings of the school district.

There are 88 public buildings having a total cubic contents of 32,300,000 cu. ft. and an average per building of 367,000 cu. ft. More than half the buildings contain over 250,000 cu. ft. of space and several are much larger. The cost of fuel for all the buildings averaged 3.1 mills per cu. ft. The figures given in the report include the fuel furnished the custodians of the buildings for their residences, except in the case of seven buildings. In what follows is a brief summary of the conclusions:

Grouping the buildings according to the type of heating plant used gives the following results:

Group No. 1, steam hot blast, using fuel oil, average cost 3.5 mills per cu. ft.

Group No. 2, direct radiation, using fuel oil, average cost 3.6 mills per cu. ft.

Group No. 3, steam hot blast, using coal for fuel, average cost 2.8 mills per cu. ft.

Group No. 4, direct radiation, using coal, average cost 2.9 mills per cu. ft.

Group No. 5, frame and brick buildings heated by stoves, average cost 4.1 mills per cu. ft.

Group No. 6, schools heated by hot-air furnaces, using coal, average cost 3.6 mills per cu. ft.

Contrasting two of the buildings, the writer states:

"Central High School shows a cost of 2.7 mills per cu. ft. while Northeast shows a cost of 2.5 mills per cu. ft. The cubic contents of Northeast High is greater than Central High, and the difference in the cost per cu. ft. for heating the two buildings is, in my opinion, due to the fact that Central High has metal frames and sash while Northeast has wooden frames and sash, and the leakage of air or wind around metal sash is greater than with wooden sash. Both these buildings use coal for fuel. As a rule the high cost of heating certain buildings is caused by metal frames and sash, while in other buildings it is due to poor construction, taking into account their age, etc."

Another point is the fact that where mechanical ventilation, or what is known as hot blast fan system, using coal for fuel, is installed, the cost for heating per cu. ft., is less on an average than the others, being 2.8 mills.

The fact that the figures for schools equipped with mechanical ventilation run less than for those not so equipped may be attributed to automatic temperature control. The highest cost per cu. ft. is shown where stoves are used for heating, being 4.1 mills.

[1] Chief Engineer and Supt. of Buildings, The School District of Kansas City, Mo. Mem. Am.Soc.M.E.

G. D. Bagley.[1] The insulation of heated surfaces to conserve radiation and convection losses often does not receive the attention which it deserves. Such insulation is necessary regardless of the purpose of the installation or the method of heating. Coverings of the proper thickness and material applied to power plants, chemical plants, heating systems, etc., result in a large saving in coal and a high rate of return on the investment.

The losses from such surfaces range from 2 to 10 B.t.u. per sq. ft. per hour per deg. fahr. temperature difference, at the temperatures at which steam is used and amount to 300 tons of coal per year for every 1000 sq. ft. of exposed surface at 100 lb. steam pressure.

The Mellon Institute of Industrial Research has been engaged for some time in making a study of heat insulating materials for the Magnesia Association of America, and in order to check up the results of the laboratory work under practical conditions a set of tests was made on a boiler before and after covering with magnesia.

The tests were made at a mine at Bruceton, Pa., in conjunction with the Bureau of Smoke Regulation of the City of Pittsburgh. The two boilers used in the tests were of the locomotive type, 60 and 80 hp., fire tubes and single pass. They were installed on concrete piers without coverings. The total uncovered surface was 675 sq. ft. and the average pressure 80 lb. per sq. in.

Each test covered a period of 24 hours. The firing was under the supervision of the Bureau of Smoke Regulation in order to have it as consistent and regular as possible. The coking method was used, firing the coal in the front of the furnace, leaving the fire door open for a short time after each firing, and breaking the coal back as it coked. This method of

[1] Mellon Institute, Pittsburgh, Pa.

procedure resulted in nearly smokeless combustion of the fuel.

During the first test, 10,784 lb. of coal were used and 58,000 lb. of water were evaporated. This corresponds to a rate of 6.35 lb. of water from and at 212 deg. fahr. per lb. of coal as fired.

After the first test was completed, the boiler was covered with 1½ in. of magnesia blocks, and plastered with magnesia cement and a coal of hard-finish cement for protection, making a total thickness of about 2 in. The boiler test was then repeated, taking great care to hold the load at the same values as during the first test, and to keep all other conditions the same.

In the second test, 59,500 lb. of water were evaporated and 9296 lb. of coal consumed, giving a rate of 7.55 lb. of water from and at 212 deg. fahr. per lb. of coal as fired and a saving of 1488 lb. of coal per day.

If calculated for an equal water evaporation, the saving would be 1700 lb. of coal. It seemed much easier to hold a nearly uniform pressure after the boilers were covered and this probably accounts for the excess of the measured saving over that calculated, as the coal was burned more uniformly and the boiler efficiency was higher.

The saving in coal as shown by this test amounted to about 15 per cent of the coal originally burned. The per cent saving will vary with the amount of exposed surfaces in proportion to the capacity of the boilers. The losses shown by the test are those due to heat loss from the boiler alone and do not take into account the losses from the pipe lines which cause condensation and wet steam in addition to wasting coal.

The tests show that the losses from uninsulated surfaces are large enough to amount to a very considerable factor in the total coal consumption of the country, and to warrant every one who is interested in the conservation of fuel in seeing that all surfaces, however small, are properly insulated.

VICTOR J. AZBE. In regard to smoke prevention, if we would base our studies upon furnace volume, gas velocity, composition of volatile matter, and take into consideration eddies and whirls, dead space, etc., we soon would have information enough collected to design furnaces for any type boiler and any fuel so smoke would not be produced. That most furnaces are built upon unscientific principles can be shown by a study of gas flow with a fairly accurate anemometer in a cold boiler when the damper is open.